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TECHNICAL MEMORANDUM

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CIVIL ENGINEERING LABORATORY
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Airfield Pavement Condition Survey and Pavement Evaluation, USMCAS, El Toro, CA

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53-024

by

L. J. Woloszynski

ABSTRACT

The results of a condition survey and friction tests on the runway at the U.S. Marine Corps Air Station, El Toro, California are presented. Additionally, plate load test results and load ratings for the asphaltic concrete portion of Runway 16R-34L and the asphaltic concrete portion of Runway 7L-25R west of runway 16L-34R are reported.

The condition survey established statistically-based condition numbers (weighted defect densities) which were direct indicators of the condition of the individual pavement facilities. The runway friction measurements showed the aircraft hydroplaning/skidding potential of the field. The results of the condition survey show that on portland cement concrete pavements, continuing maintenance has generally reduced the number of spalls and joint seal defects. On asphaltic concrete pavements, the number of cracks has increased somewhat. Runway friction measurements show all runways range from marginal to good in frictional resistance.

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INTRODUCTION

In October 1969, the Naval Facilities Engineering Command authorized a series of periodic pavement condition surveys to be conducted at Naval and Marine Corps Air Stations. The purpose of these condition surveys was to determine the suitability of the airfield pavement surfaces for aircraft operations and to establish a uniform basis for maintenance and repair efforts. A precursor condition survey was conducted at the U.S. Marine Corps Air Station, El Toro, California by the Naval Civil Engineering Laboratory* in July 1969 and reported in reference (1). Commencing in FY-75, pavement condition surveys will be performed only on active runways, and increased emphasis will be placed on determining runway friction coefficients. During the month of January, 1975, a second pavement condition survey and runway friction measurements were made at USMCAS El Toro by CEL. The survey consisted of a sophisticated, statistically-based procedure of pavement defect measurement which permitted the establishment of condition numbers (weighted defect densities) which are direct indicators of the condition of airfield pavement facilities. Runway friction measurements were made using a Mu-Meter, a small friction measuring trailer. Surface plate load tests were performed on two newly reconstructed asphaltic concrete sections of the runways and the load ratings were determined.

Additional survey efforts included photographic coverage of pavement defect types, updating of the construction history of the airfield, compilation of current aircraft traffic data, summarization of climatological data, and delineation of requirements for further pavement evaluation efforts at the station.

BACKGROUND

The U.S. Marine Corps Air Station, El Toro, is located in Orange County, six miles southeast of Santa Ana, California, at an elevation of 383 feet. An aerial photograph of the station is shown in Figure 1. The airfield has four major runways and one auxiliary runway. Two of the major runways, 7R-25L and 7L-25R are 8,100 feet long and lie parallel in a generally east-west direction. The other two major runways, 16L-34R and 16R-34L are parallel in a generally north-south direction and are 10,000 feet and 6,300 feet long, respectively. The auxiliary runway, 3-21 is 6,900 feet long and lies in a northeast-southwest direction. It is used primarily during seasonal strong easterly winds from the California deserts (known locally as "Santa Ana" winds).

CONSTRUCTION HISTORY

Original construction of the two major asphaltic concrete runways (7L-25R and 16R-34L) was completed in 1942. The two portland cement concrete runways (7R-25L and 16L-34R) were constructed in 1944 and overlaid with

* On 1 January 1974, redesignated the Civil Engineering Laboratory (CEL) of the Naval Construction Battalion Center, Port Hueneme, California

asphaltic concrete in 1951. During the ensuing years since the original construction, extension and strengthening of the runways and taxiways has been accomplished, along with the addition of taxiways and parking aprons. A complete history of construction and recorded maintenance is provided in Appendix A.

CURRENT AIRCRAFT TRAFFIC

A tabulation of the number of aircraft operations for a 12 month period is shown in Table 1. Table 2 lists the aircraft normally using USMCAS El Toro and a three-month record of the number of sorties for each aircraft type.

CLIMATOLOGICAL DATA

A summary of climatological data for USMCAS El Toro is presented in Appendix B.

PAVEMENT CONDITION SURVEY

Condition Survey Procedure

The condition survey procedure used at USMCAS El Toro was developed by CEL in 1968. This procedure permits the establishment of condition numbers (weighted defect densities) which are direct indicators of the pavement surface condition. A complete description of the pavement condition survey procedure is presented in Appendix C. It should be noted that Appendix C describes procedures for both asphaltic concrete (AC) and portland cement concrete (PCC) pavements, and includes other pavement facilities in addition to runways. At USMCAS El Toro, only the runways were surveyed. Discrete areas were selected after a preliminary inspection of the runways. The locations of the discrete areas are shown in Figure 2. Defect severity weights as used at USMCAS El Toro are given in Table 3.

Results of Condition Survey

The results of the survey of each discrete area are shown in the Discrete Area Defect Summary sheets, pages through of this report. Each Discrete Area Defect Summary includes a narrative description of the pavement defects encountered. In addition, photographs of typical pavement conditions noted during the survey can be seen in Figures 3 through 6 .

Total weighted defect densities range from 0.00C (no visible defects) for discrete area R16R-3 to 3.42C for discrete area R3-2 on portland cement concrete pavements. Asphaltic concrete defect densities range from 0.00A for discrete areas R16-1 and R7L-2 to 12.28A for discrete area R3-1.

An analysis of the change in pavement condition since the last condition survey is given in the Discrete Area Condition Analysis sheets, pages 61 through 74.

RUNWAY FRICTION MEASUREMENTS

The skid resistance/hydroplaning characteristics of the runway surfaces were evaluated with a Mu-Meter friction measuring device. The test program consisted of field measurements of skid resistance/hydroplaning potential under standardized, artificially-wet conditions. In addition, both transverse and longitudinal pavement slopes were measured at intervals along each runway centerline to evaluate surface drainage characteristics.

Test Locations

Three or four test sections on each runway were selected to provide a representative sample of the skid resistance properties of each runway. The test section layout is shown in Figure 7. The test sections were selected to provide pavement friction data in: (a) the aircraft touch-down areas, and (b) the runway interior where maximum braking is normally developed.

Test Equipment

The principal items of test equipment used were the Mu-Meter, a tank truck for water application, and a device for measuring pavement slopes.

The Mu-Meter is a small trailer, designed and manufactured by M. L. Aviation of Maidenhead, England. It measures the side-force friction coefficient generated between the pavement surface and the pneumatic tires on the two wheels which are set at a fixed toe-out (yaw angle) to the line of drag. The Mu-Meter is a continuous recording device that graphically records the coefficient of friction, mu* versus the distance traveled along the pavement.

The water truck provided by the station was a runway foamer with a spray nozzle and pumping system calibrated to place 0.1 inch of water on the skid test strip with each pass.

The slope measuring device consisted of a rectangular aluminum section (10 feet long, 1 inch thick, and 4 inches high) with machinists' levels attached to define slope from 0 to 2.5 percent.

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* The symbol mu or μ designates the coefficient of friction which is a constant used to represent the ratio of frictional force to force normal to the pavement surface.

Test Procedures

The field test procedures utilized at USMCAS El Toro are those outlined in NAVFAC INSTRUCTION 11132.14B. The methods were:

(1) A preliminary reconnaissance of the pavement surfaces was made and representative test areas (each 1000 feet long) were selected for skid testing.

(2) Transverse and longitudinal slope measurements were made at approximately 500-foot intervals along the runway. Transverse measurements were made at two places on each side of the centerline covering a distance of approximately 20 feet. Longitudinal measurements were made on the centerline at the same stations where the transverse measurements were made.

(3) The water truck, which had been calibrated to apply 0.1 inch of water each time it passed over a test strip, made two passes over the test strip.

(4) Mu-Meter runs at 40 miles per hour, 1.2 times the theoretical hydroplaning speed for this vehicle, were initiated immediately after completion of the second water truck pass. Mu-Meter runs were made in alternate directions at convenient time intervals until a dry pavement condition was reached or 30 minutes had elapsed.

(5) All water truck and Mu-Meter operations were measured to the nearest second using a stop watch.

Runway Friction Test Results

The pavement skid resistance results are reported in terms of mu, coefficient of friction, as measured by the Mu-Meter. The actual friction coefficient versus distance traces as recorded by the Mu-Meter during the first run after wetting for each test section are shown in Figures 8 through 14. The traces show the variation of friction coefficient within each test section. Sharp dips in the curves indicate areas of lower friction values. Appendix D contains all test results for each Mu-Meter test section.

Figures 16 through 23 show changes in surface friction coefficient versus time after wetting for each pavement section tested. (Note that the time intervals after wetting at which skid tests were made often differed from one test to another, due to small variations in water truck speed and Mu-Meter adjustments). These graphs demonstrate the natural drainage characteristics of the runway surface and the time required to return to an essentially dry condition or a consistently high friction coefficient.

A summary of test data and an associated Mu-Meter aircraft pavement rating guide are presented in Tables 4 and 5. The rating guide was developed from the results of an Air Force Weapons Laboratory research program and a joint NASA/AF/FAA test program using actual aircraft correlated with Mu-Meter skid coefficient results. While the current state-of-the-art does not allow a more precise delineation of exact aircraft responses, the rating guide provides a good rule-of-thumb for interpretation of test data.

Table 4 presents the average skid resistance values for each skid test section. From the curves presented in Figures 15 through 22, values of mu were determined for time periods of 3, 15, and 30 minutes after water was applied. The coefficient determined at 3 minutes after water application corresponds to a wet runway condition, and the coefficient determined at 15 minutes after water application corresponds to a damp runway condition. At 30 minutes after wetting, the friction coefficient can be considered a dry pavement condition. The curves in Figures 15 through 22 were extrapolated, if necessary, to obtain friction coefficients at those time intervals. These data indicate the rate the pavement skid resistance properties were recovered after the test sections were wetted. By comparing the actual values of mu shown in Table 4 with the expected aircraft response in the associated rating guide, Table 5, it is possible to evaluate aircraft hydroplaning potential.

Measured pavement slopes are shown in Table 6. Positive transverse slopes indicate that water drains to the runway edge without crossing the centerline, while negative transverse slopes indicate that water crosses the runway centerline before draining to the edge. Positive longitudinal slopes indicate rising pavement grades in the direction of increasing runway stations while negative longitudinal slopes indicate falling grades in the direction of increasing stations.

DISCUSSION OF RESULTS

Condition Survey Results

In the asphaltic concrete portions of Runway 3-21, the weighted defect density increased from 8.40A to 12.28A with the increase being mainly attributable to an increase in raveling and transverse and longitudinal cracking. The asphaltic concrete portion of Runway 7R-25L showed a total weighted defect density increase from 2.27A to 3.93A. The principal contributors to this increase were an increase in the amount of reflection cracking and pattern cracking. The asphaltic concrete portion of Runway 16L-34R had an increase in weighted defect density from 2.97A to 5.13A. An increase in the amount of pattern and reflection cracking contributed most of this change.

The portland cement concrete portions of the runways generally had lower weighted defect density numbers in 1975 than 1969. This decrease of defect density can be attributed to spall repairs and joint resealing that are a part of the continuing maintainance program of the station.

Runway Friction Measurements

The wet (3 min.) friction coefficients on all the runways tested at MCAS El Toro varied from marginal to good. The damp (15 min.) coefficients are all above the good rating. This indicates that all the runways exhibit good drainage characteristics.

Pavement Evaluation Tests

The recently rebuilt sections of Runways 7L-25R (Discrete Area R7L-2) and 16R-34L (Discrete Area 16R-1) were load tested to determine their maximum wheel load capability. (See Figure 23 for test locations). Each was subjected to three load tests under a 30-inch diameter plate and three load tests under an 8-inch diameter plate at the stations where the previous (1963) pavement evaluation had revealed the lowest loads of the 30-inch plate that produced a 0.15 inch deflection. Table 7 shows load ratings for these areas only. Note that some ratings based on the tests conducted in 1963 were higher than the ratings based on the tests in 1975 on the recently rebuilt pavement. It is conjectured that the plate tests on the asphalt in 1963 were on 12 year old stiff and brittle asphaltic concrete that required higher loads to achieve the 0.15-inch deflection. It is also to be noted that the tests in 1963 were run in November, the time of year when the "sandwich" type of pavement construction was at its driest condition. The rainy season in this area is later in the winter months. The present assumption that the 1963 load ratings were too high is further borne out by the fact the pavement did indeed require reconstruction.

RECOMMENDATIONS FOR FURTHER EVALUATION EFFORT

It is recommended that a pavement condition survey be repeated in five years in a continuing effort to monitor airfield pavement conditions.

REFERENCES:

1. U.S. Naval Civil Engineering Laboratory Technical Note N-1089: Airfield Pavement Condition Survey, USMCAS El Toro, California, by D. J. Lambiotte, Port Hueneme, CA, April 1970

2. U.S. Naval Civil Engineering Laboratory, Technical Note N-592: Airfield Pavement Evaluation, USMCAS, El Toro, California, by Robert J. Lowe, Port Hueneme, CA, April 1964

TABLE 1. AIRCRAFT OPERATIONS DATA
USMCAS EL TORO, CA

DATE	OPERATIONS
Jan 74	8,867
Feb 74	10,469
Mar 74	12,490
Apr 74	12,477
May 74	12,036
Jun 74	9,428
Jul 74	10,848
Aug 74	11,696
Sep 74	10,471
Oct 74	11,579
Nov 74	10,964
Dec 74	9,856
Total Operations	131,181
Average monthly operations	10,931

TABLE 2. TYPES OF AIRCRAFT AND OPERATIONS DATA FOR AIRCRAFT USING USMCAS EL TORO

	Sorties (one landing and one takeoff)		
	Oct 74	Nov 74	Dec 74
C-131	21	13	18
KC-130	224	173	181
C-117	93	105	81
F-4 & RF-4	1,647	1,122	1,407
A-4 & TA-4	563	1,155	994
A-6 & EA-6	141	219	116
T-28	81	99	77
T-39	47	36	37
OV-10	383	320	283
HH-1K	65	78	74
CH-46	554	576	496
CH-53	405	391	308
AH-1	251	310	243

TABLE 3. DEFECT SEVERITY WEIGHTS

AIRFIELD: USMCAS EL TORO, CALIFORNIA

Asphaltic Concrete Defect	Weight	Portland Cement Concrete Defect	Weight
Depression	9.0	Depression	9.0
Rutting	9.0	Shattered Slab	9.0
Broken-up Area	9.0	Faulting	8.5
Faulting	8.5	Spalling	7.5
Raveling	7.0	Scaling	7.0
Erosion-Jet Blast	7.5	"D-Line" Cracking	6.5
		Pumping	4.0
Longitudinal, Transverse, or Longitudinal Construction Joint Crack	3.0	Poor Joint Seal	3.0
Pattern Cracking	3.0	Corner Break	3.0
Patching	3.5	Intersecting Crack	3.0
Reflection Crack	1.5	Longitudinal or Transverse Crack	1.5
Oil Spillage	1.5		

TABLE 4. RUNWAY FRICTION MEASUREMENT SUMMARY USMCAS EL TORO, CALIFORNIA

Test Location	Friction Coefficients		
	3 Min. (Mu)	15 Min. (Mu)	30 Min. (Mu)
Runway 7L-25R			
Test Section A	.33	.58	.63
Test Section B	.77	.84	.84
Test Section C	.34	.65	.80
Runway 7R-25L			
Test Section A	.49	.82	.85
Test Section B	.70	.78	.80
Test Section C	.70	.86	.87
Test Section D	.52	.80	.80
Runway 16L-34R			
Test Section A	.38	.60	.72
Test Section B			
AC Portion	.37	.58	.72
PCC Portion	.37	.62	.75
Test Section C	.50	.80	.85
Test Section D	.75	.79	.80
Runway 16R-34L			
Test Section A	.73	.82	.82
Test Section B	.55	.78	.81
Test Section C			
AC Portion	.57	.79	.83
PCC Portion	.70	.79	.80

TABLE 5. MU-METER AIRCRAFT PAVEMENT RATING

Mu	Expected Aircraft Braking Response	Hydroplaning Potential
Greater than 0.50	Good	No hydroplaning problems are expected
0.42 - 0.50	Fair	Transitional
0.25 - 0.41	Marginal	Potential for hydroplaning for some aircraft exists under certain wet conditions
Less than 0.25	Unacceptable	Very high probability for most aircraft to hydroplane

TABLE 6. RUNWAY SLOPE MEASUREMENTS
USMCAS EL TORO, CA

Location	Transverse Slopes Left Percent	Left Percent	℄ Right Percent	Right Percent	Longitudinal Slopes Percent
Runway 16L - 34R					
0+00	-1.3	-0.8	+1.3	+1.3	0.0
5+00	-0.6	-0.7	+0.5	+0.6	-0.1
10+00	-1.5	-1.5	+1.7	+1.5	-0.3
20+00	-1.7	-1.7	+1.4	+1.5	-0.4
30+00	-0.7	-1.1	+1.0	+1.3	-0.4
37+00	-1.1	-1.3	+1.2	+0.5	-0.9
42+00	-0.7	-1.7	+0.7	+1.3	-0.8
47+00	-1.2	-1.7	+1.2	+0.9	-0.9
55+00	-0.8	-1.1	+1.2	+1.5	-0.8
65+00	-1.4	-1.8	+0.8	+0.7	-0.6
75+00	-1.2	-1.0	+1.0	+1.5	-0.9
80+00	-1.2	-1.0	+1.3	+0.8	-1.0
85+00	-1.2	-0.8	+1.5	+1.4	-0.8
90+00	-1.0	-0.9	+0.9	+1.2	-0.4
100+00	-0.9	-0.9	+1.2	+0.9	-0.8
Runway 16R - 34L					
0+00	-0.4	-0.2	+0.8	+1.0	0.0
5+00	-1.6	-1.2	+1.8	+1.8	+0.2
10+00	-1.3	-1.5	+1.7	+1.4	+0.4
15+00	-1.0	-1.2	+1.2	+1.4	-0.8
25+00	-0.9	-0.9	+1.0	+1.4	-0.6
30+00	-1.0	-1.2	+0.8	+1.0	-1.0
35+00	-0.7	-1.0	+0.8	+1.0	-0.8
53+00	-0.8	-1.0	+0.8	+0.9	-0.8
58+00	-0.7	-1.0	+0.8	+0.9	-1.0
63+00	-0.5	-0.9	+0.9	+1.1	-0.8

NOTE: Positive transverse slopes indicate water drains to the runway edge without crossing the center line, while negative transverse slopes indicate drainage across the centerline. Positive longitudinal slopes indicate rising grades in the direction of increasing runway stationing, while falling grades are negative.

TABLE 6. RUNWAY SLOPE MEASUREMENTS
USMCAS EL TORO, CA

Location	Transverse Slopes Left Percent	Percent	℄ Right Percent	Percent	Longitudinal Slopes Percent
Runway 7L - 25R					
0+00	-1.0	-0.2	+1.3	+0.9	+1.5
5+00	-0.8	-0.5	+0.8	+0.2	+1.6
10+00	-0.2	-0.3	+0.7	+0.9	+1.4
15+00	+0.5	+0.3	+0.8	+0.6	+1.4
20+00	+0.9	+0.5	+0.7	+0.6	+1.7
30+00	+0.5	+0.5	+1.0	+0.9	+1.4
40+00	-1.0	-0.3	+0.9	+0.8	+1.6
50+00	-0.9	-0.8	-0.5	+1.1	+1.5
60+00	-1.0	-1.0	+0.9	+0.5	+1.2
65+00	-0.9	-0.8	+1.2	+0.5	+1.5
70+00	-0.9	-0.3	+0.5	+0.6	+1.3
75+00	-1.2	-0.4	+0.5	+0.4	+1.7
80+00	-1.1	-0.9	+0.9	+0.3	+0.8
Runway 7R - 25L					
0+00	-1.3	-0.6	+1.1	+0.9	+1.8
5+00	-1.3	-1.0	+0.4	+0.2	+1.5
10+00	-0.5	-0.2	+0.9	+1.0	+1.6
15+00	-1.4	-0.7	+1.2	+0.2	+1.4
20+00	-1.5	-0.5	+0.8	+1.2	+1.2
25+00	-0.8	-1.2	+1.3	+0.5	+1.3
30+00	-0.9	-1.4	+1.3	+1.0	+1.4
35+00	-0.7	-0.8	+0.9	+0.7	+1.9
40+00	-1.2	-0.8	+1.0	+0.8	+1.3
47+00	-0.8	-0.8	+1.2	+0.8	+1.4
55+00	-1.0	-1.2	+1.2	+1.3	+1.7
60+00	-0.7	-1.3	+0.8	+0.5	+1.6
65+00	-0.5	-1.3	+0.8	+0.9	+1.4
70+00	-0.8	-1.2	+0.2	+0.9	+1.4
75+00	-1.5	-1.0	+1.0	+0.9	+1.0
80+00	-1.4	-1.2	+1.4	+1.2	+0.9

TABLE 7. LOAD RATINGS FOR ASPHALTIC CONCRETE PAVEMENTS, USMCAS EL TORO, CA (SELECTED AREAS)

Location	Allowable Gross Aircraft Loads (lbs.)*				
	Single Wheel Gear		Dual Wheel Gear	Single Tandem Gear	Dual Tandem Gear
	150 psi tires	400 psi tires	150 psi tires	150 psi tires	150 psi tires
**Condition Survey Discrete Area R16R-1	88,840	73,680	115,500	147,500	173,200
***Condition Survey Discrete Area 7L-2	88,400	70,530	114,950	146,700	172,420

* Assume 95 percent of load on main gear, 5 percent on nose gear.
** Asphaltic concrete portion of Runway 16R-34L
*** Asphaltic concrete portion of Runway 7L-25R west of Runway 16L

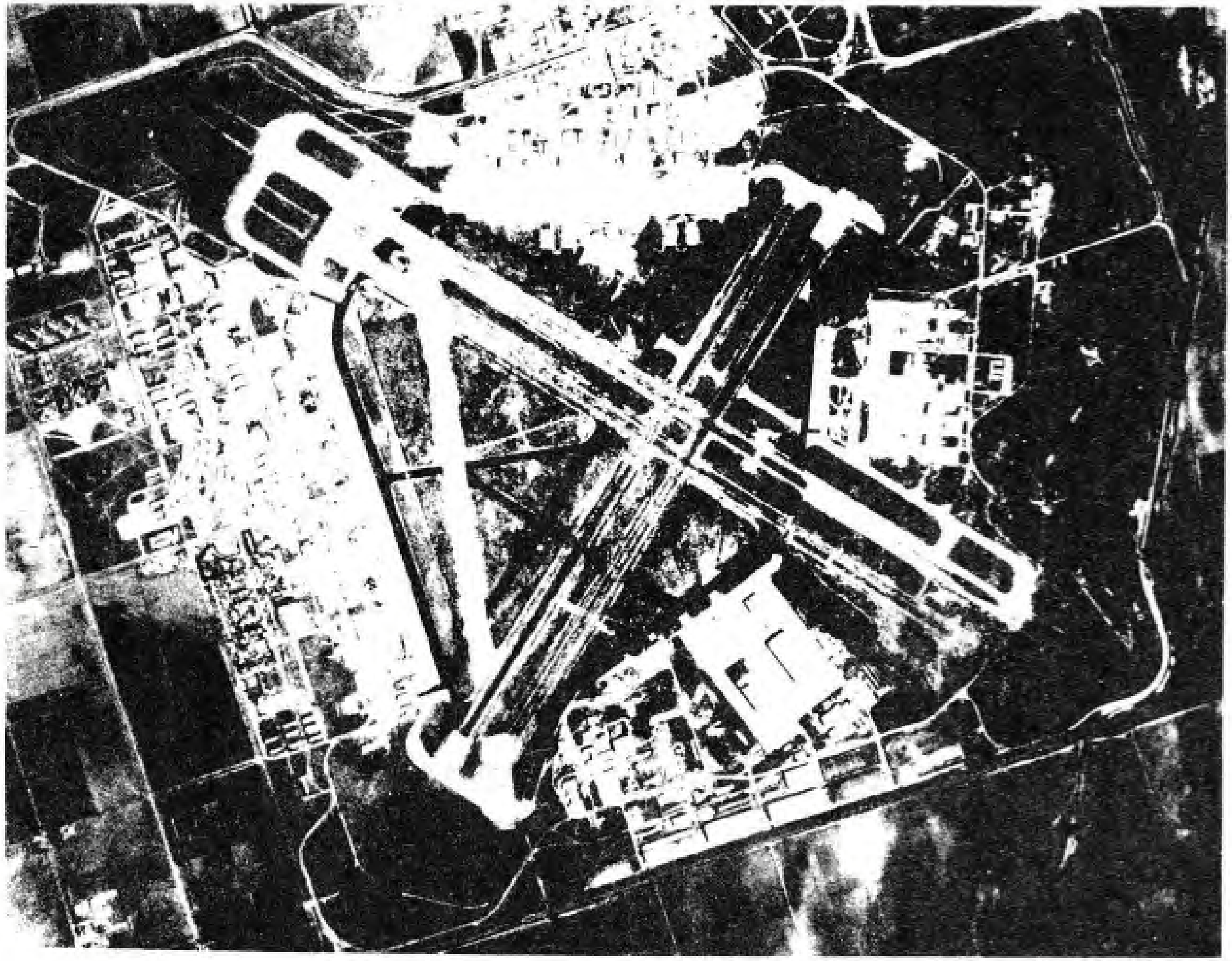


Figure 1. Aerial photograph of USMCAS El Toro, California.

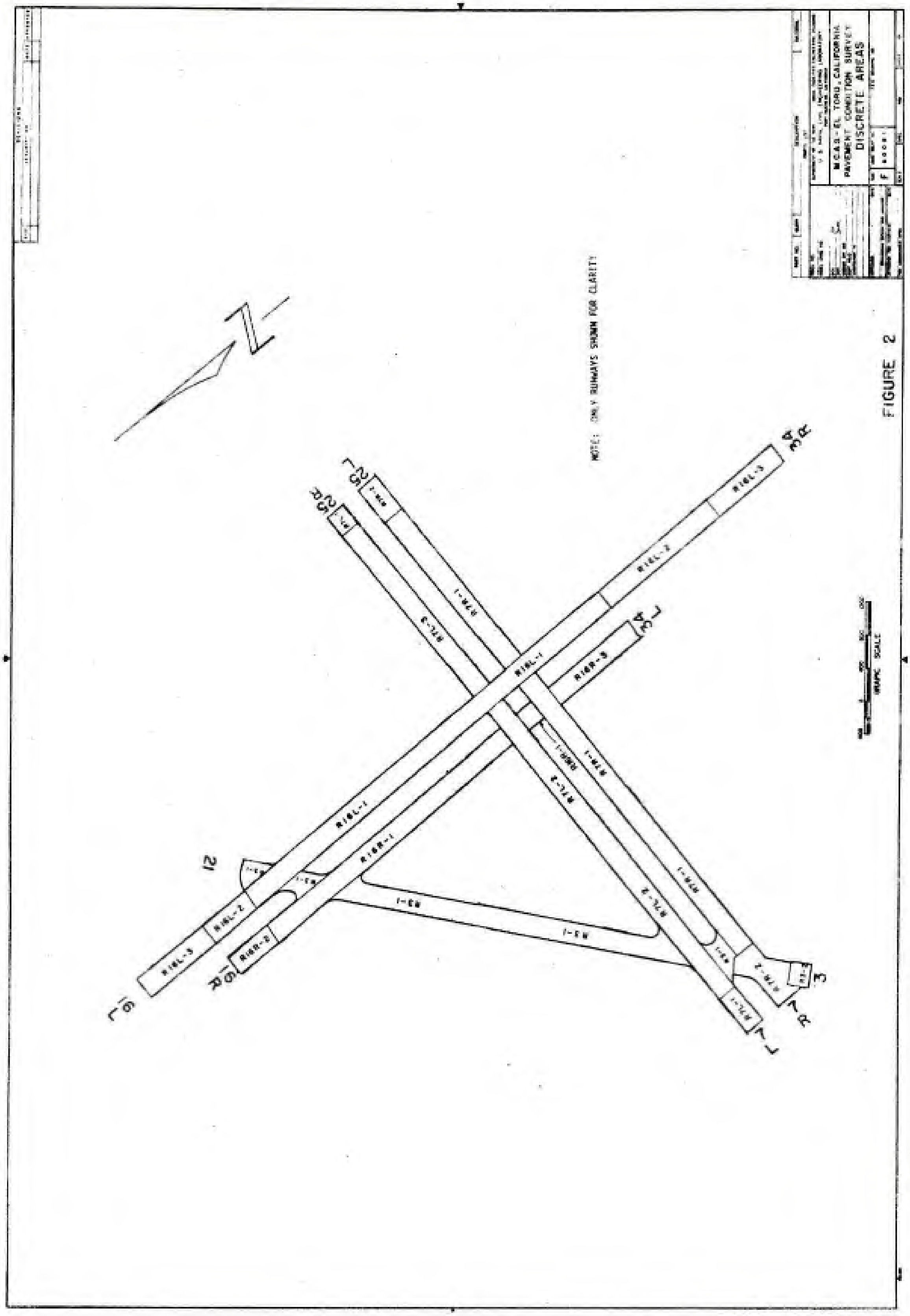

MCAS-EL TORO, CALIFORNIA
PAVEMENT CONDITION SURVEY
DISCRETE AREAS
NOTE: ONLY RUNWAYS SHOWN FOR CLARITY
GRAPHIC SCALE
R16L-1
R16L-2
R16L-3
R16R-1
R16R-2
R16R-3
R7L-1
R7L-2
R7R-1
R7R-2
R3-1
16L
16R
34L
34R
7L
7R
25L
25R
3
21

FIGURE 2

FIGURE 3. SURFACE CONDITION ASPHALTIC CONCRETE, DISCRETE AREA R3-1

FIGURE 4. REFLECTION CRACKS, DISCRETE AREA R7R-1

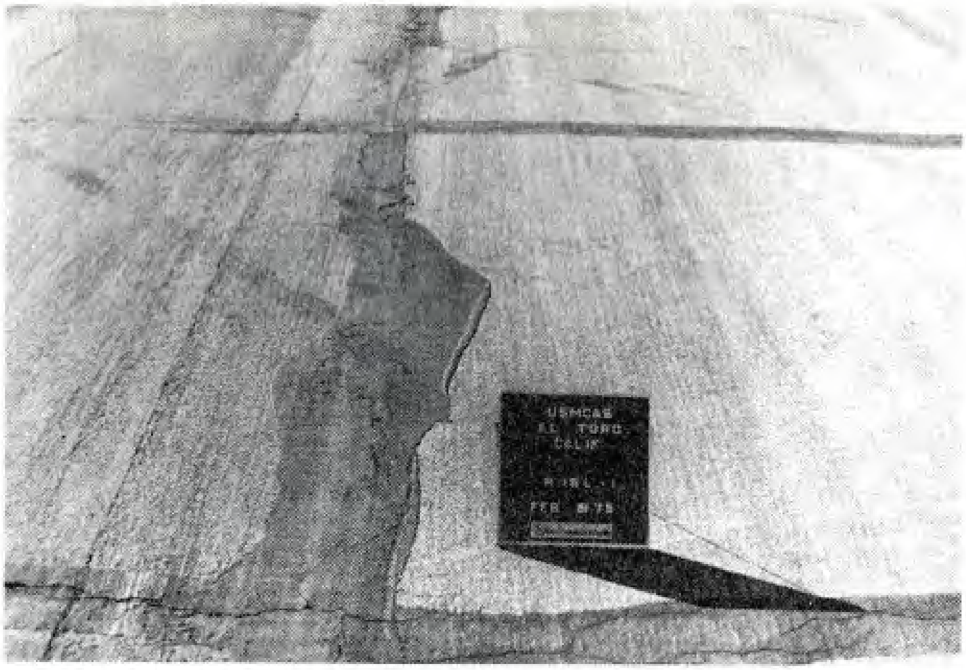


FIGURE 5. REFLECTION CRACKS, DISCRETE AREA R16L-1

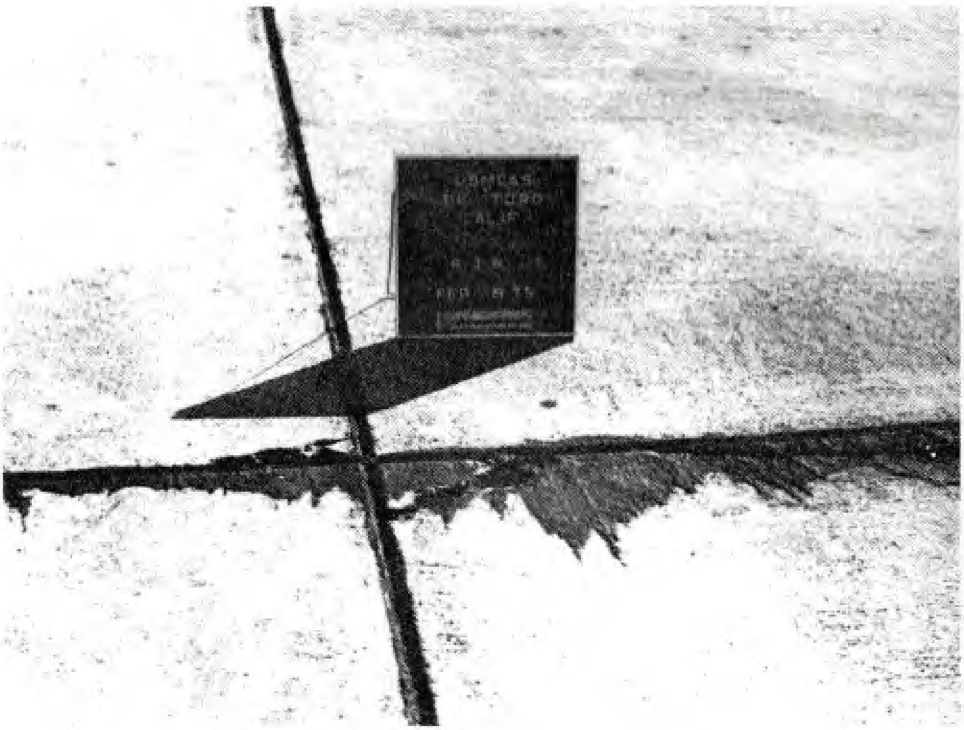
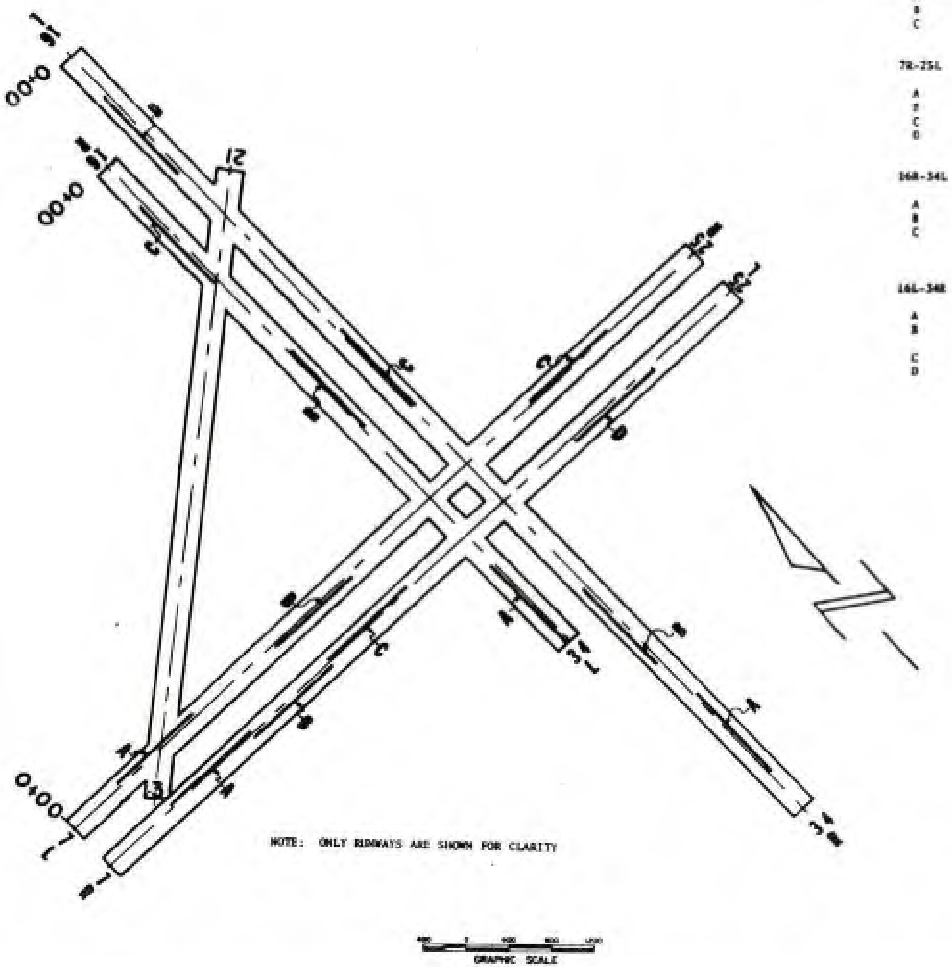


FIGURE 6. SPALL, DISCRETE AREA R7R-2

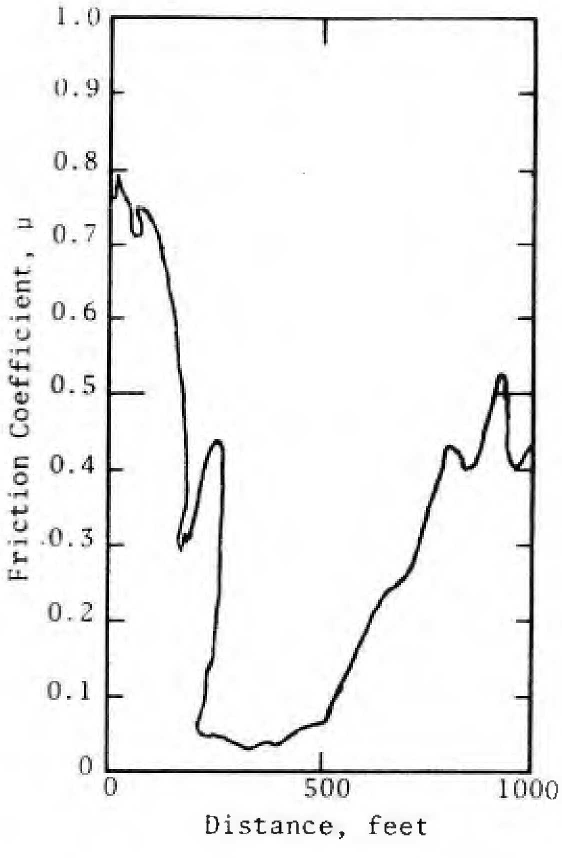
FRICTION MEASUREMENT TEST AREAS

Runway and Test Section	Station	Offset From Center Line
7L-25R		
A	5+00 to 15+00	10' L
B	25+00 to 35+00	10' R
C	60+00 to 70+00	10' L
7R-25L		
A	8+14 to 18+14	10' L
B	18+14 to 28+14	10' R
C	28+14 to 38+14	10' L
D	60+00 to 70+00	10' R
16R-34L		
A	53+11 to 63+11	10' L
B	25+00 to 35+00	10' R
C	6+30 to 15+00 (AC)	10' L
	5+00 to 6+30- (PCC)	10' R
16L-34R		
A	85+00 to 95+00	10' L
B	70+00 to 72+50 (AC)	10' R
	72+50 to 80+00 (PCC)	
C	37+00 to 47+00	10' L
D	5+00 to 15+00	10' R

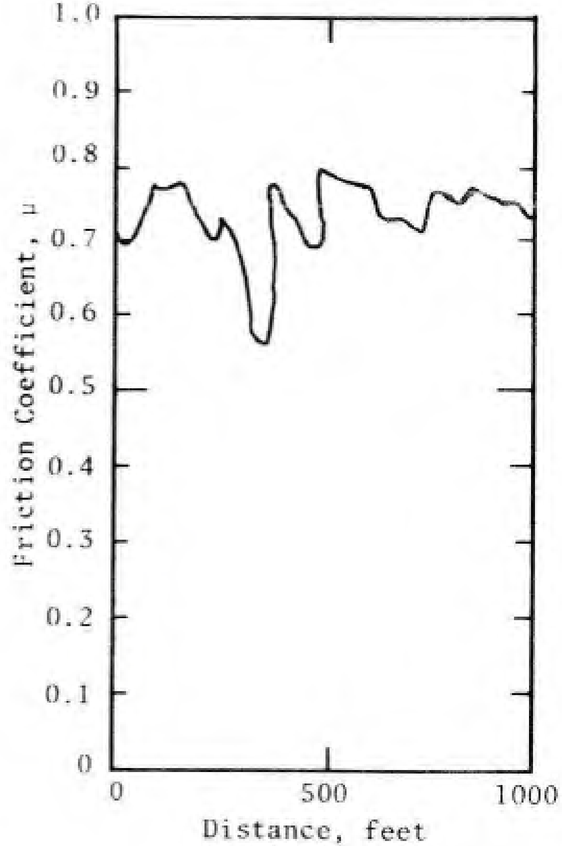


USMCAS EL TORO, CALIF
SKID TEST LOCATIONS

Figure 7

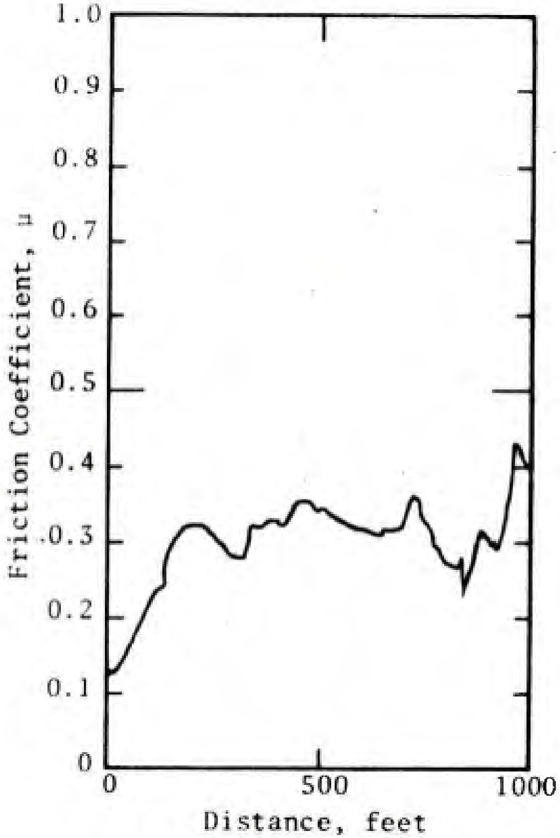


Runway 7L-25R
Test Section A-Run 1

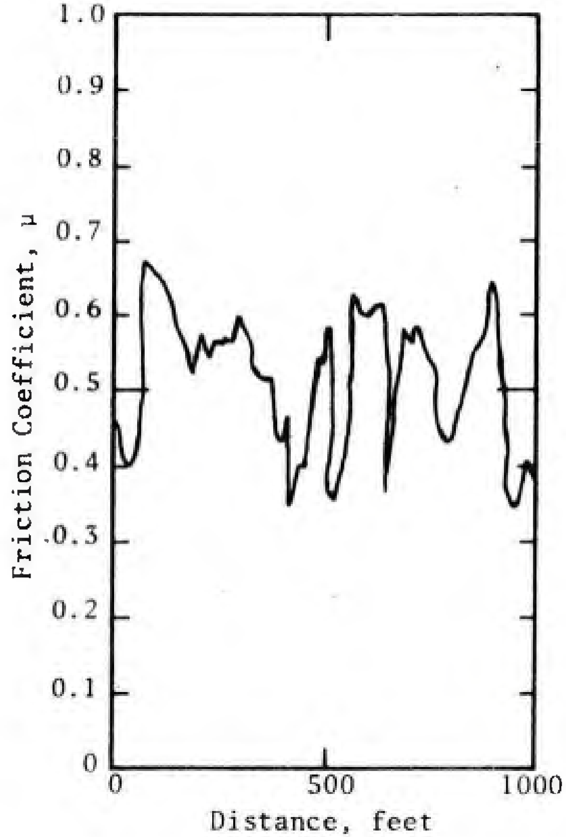


Runway 7L-25R
Test Section B-Run 1

Figure 8. Friction Coefficient versus Distance
USMCAS El Toro, CA

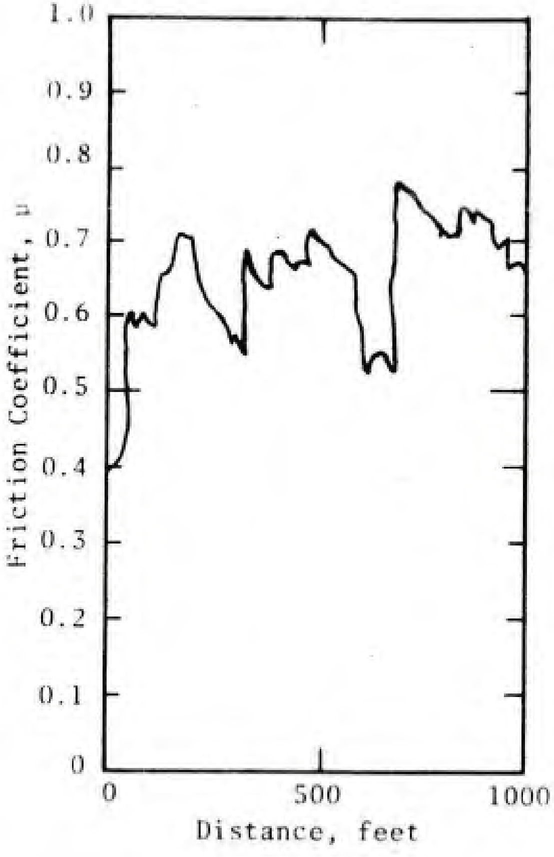


Runway 7L-25R
Test Section C-Run 1

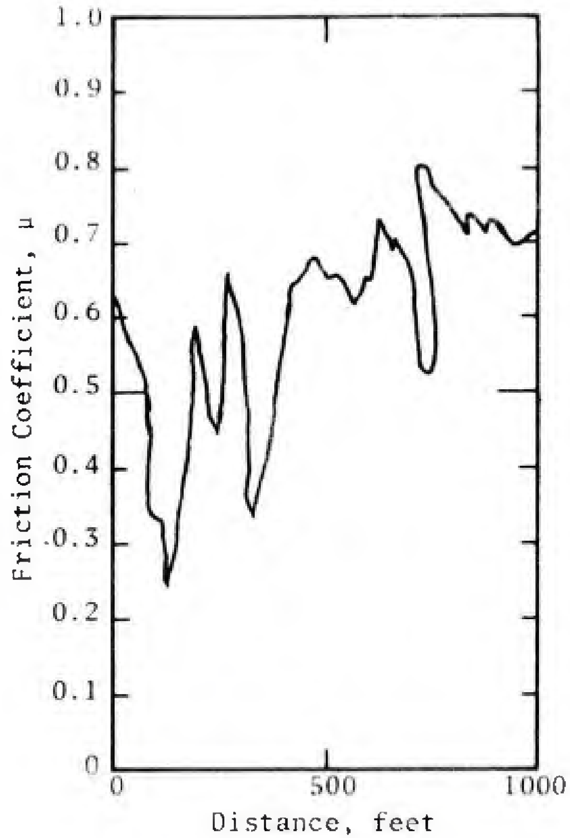


Runway 7R-25L
Test Section A, Run 1

Figure 9. Friction Coefficient versus Distance
USMCAS El Toro, CA

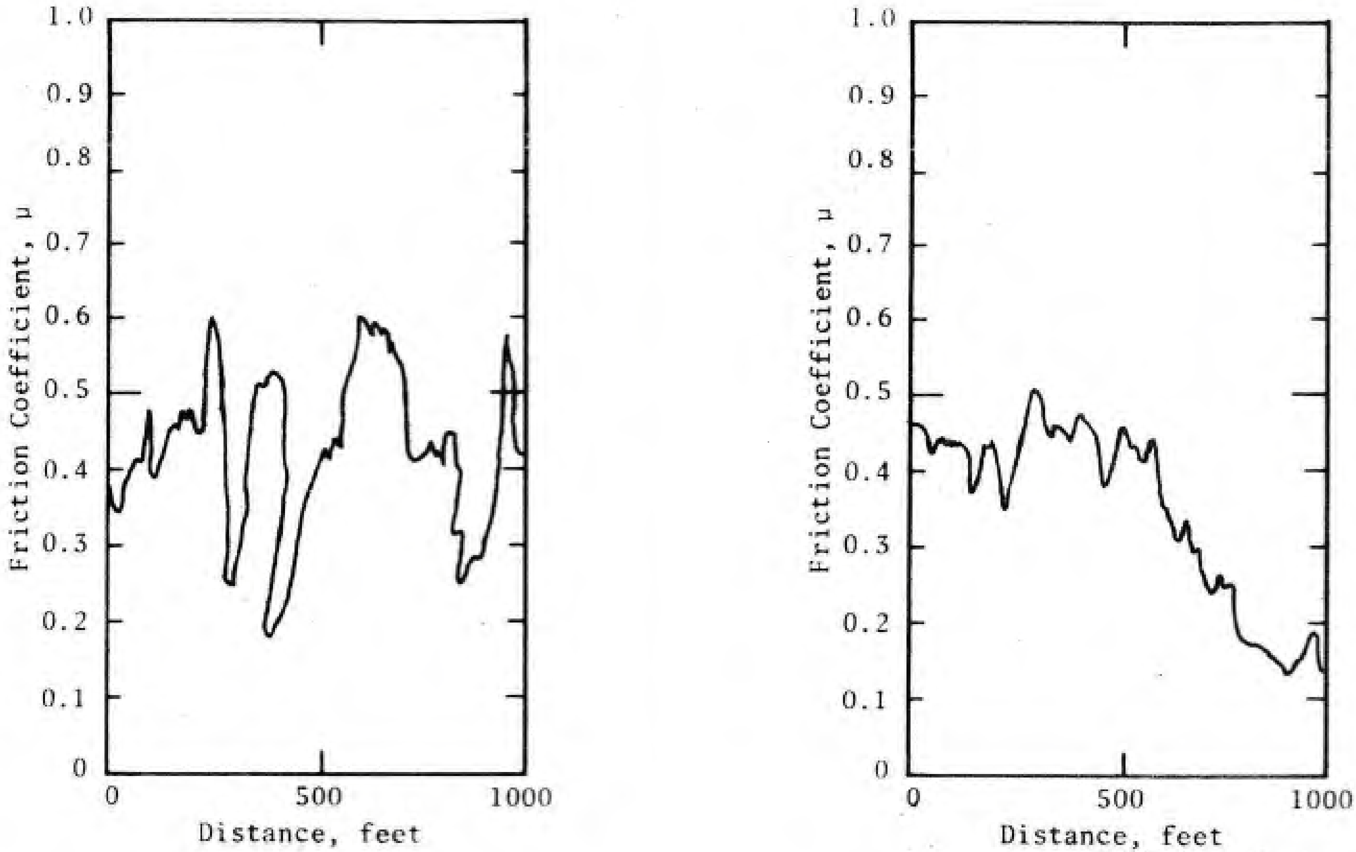


Runway 7R-25L
Test Section B, Run 1



Runway 7R-25L
Test Section C, Run 1

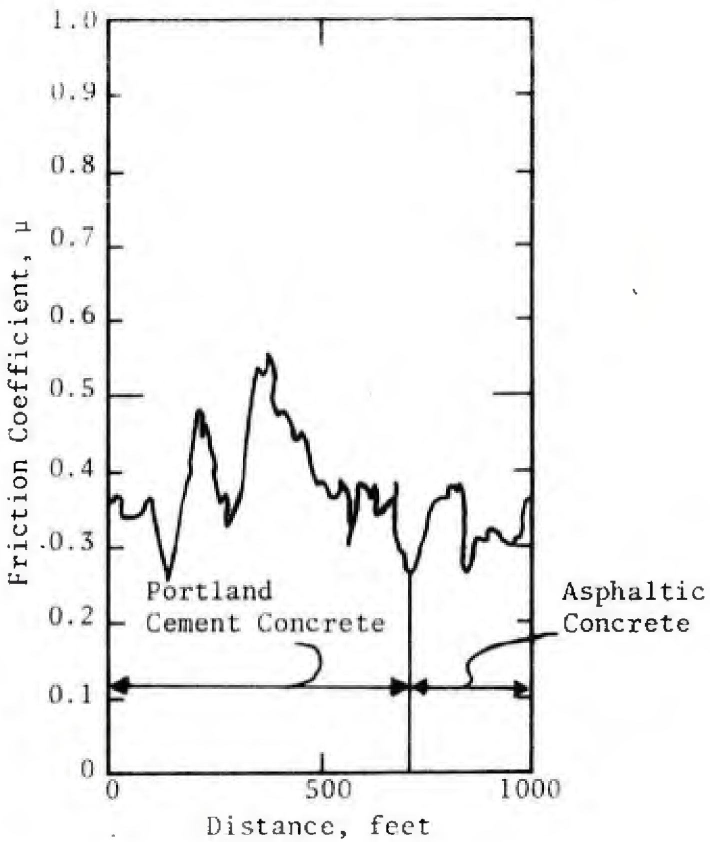
Figure 10. Friction Coefficient versus Distance, USMCAS El Toro, CA



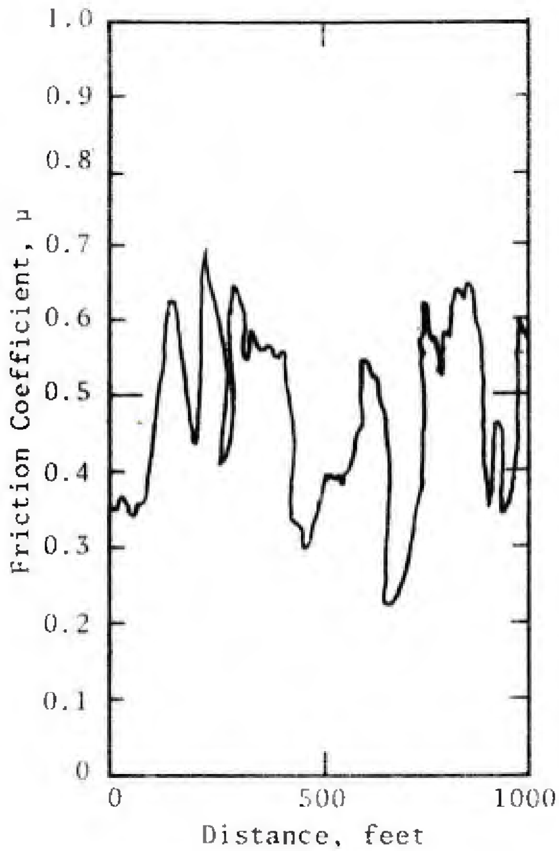
Runway 7R-25L
Test Section D, Run 1

Runway 16L-34R
Test Section A-Run 1

Figure 11. Friction Coefficient versus Distance, USMCAS El Toro, CA

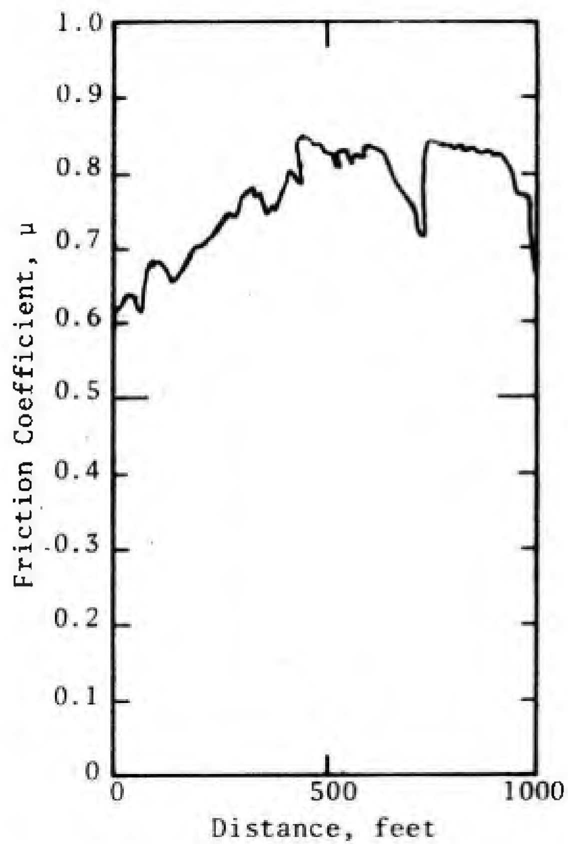


Runway 16L-34R
Test Section B-Run 1

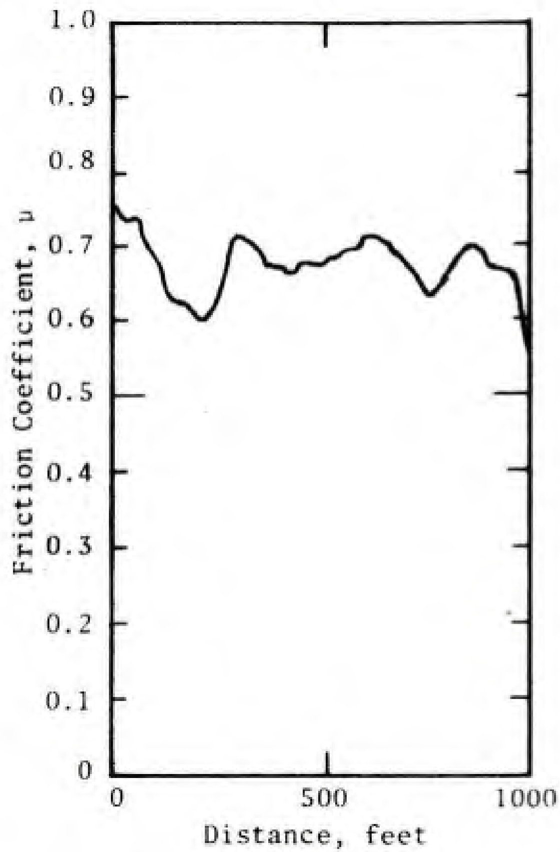


Runway 16L-34R
Test Section C-Run 1

Figure 12. Friction Coefficient versus Distance,
USMCAS El Toro, CA

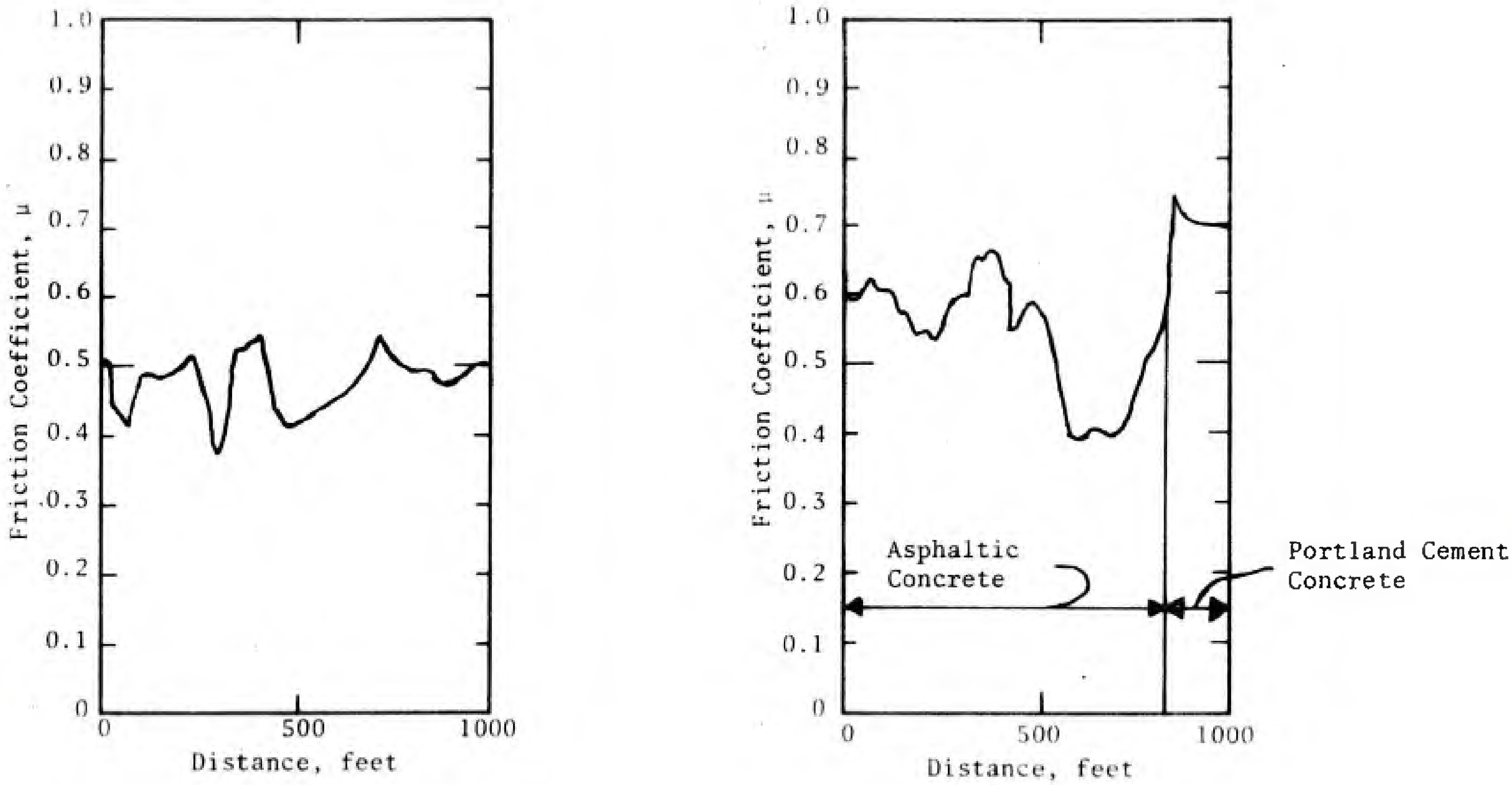


Runway 16L-34R
Test Section D-Run 1



Runway 16R-34L
Test Section A-Run 1

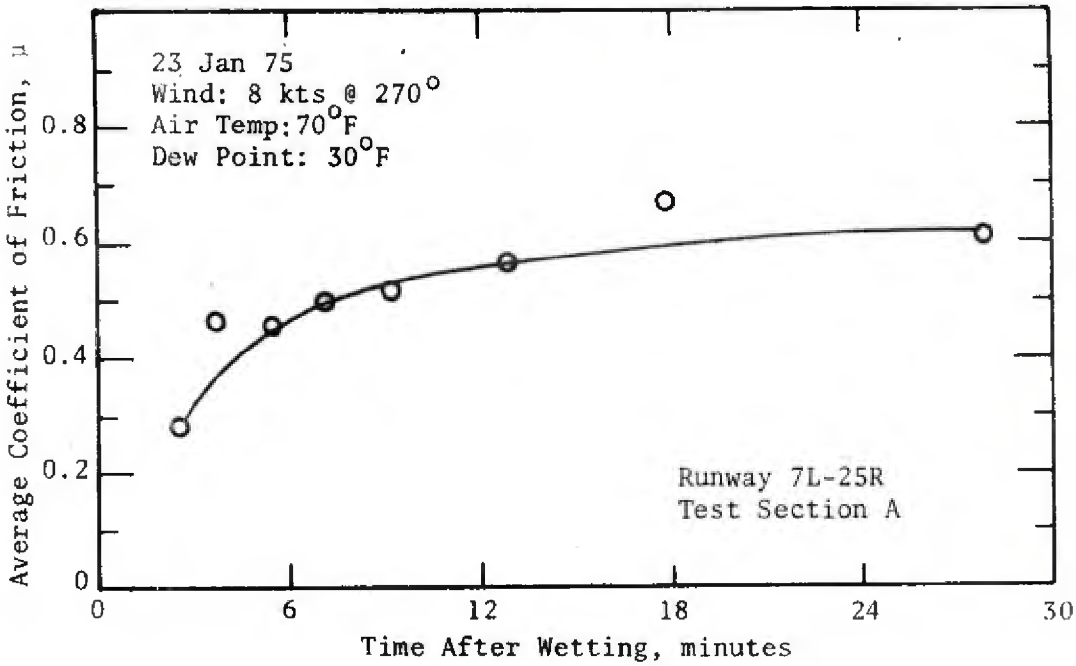
Figure 13. Friction Coefficient versus Distance
USMCAS El Toro, CA



Runway 16R-34L
Test Section B-Run 1

Runway 16R-34L
Test Section C-Run 1

Figure 14. Friction Coefficient versus Distance
USMCAS El Toro, CA



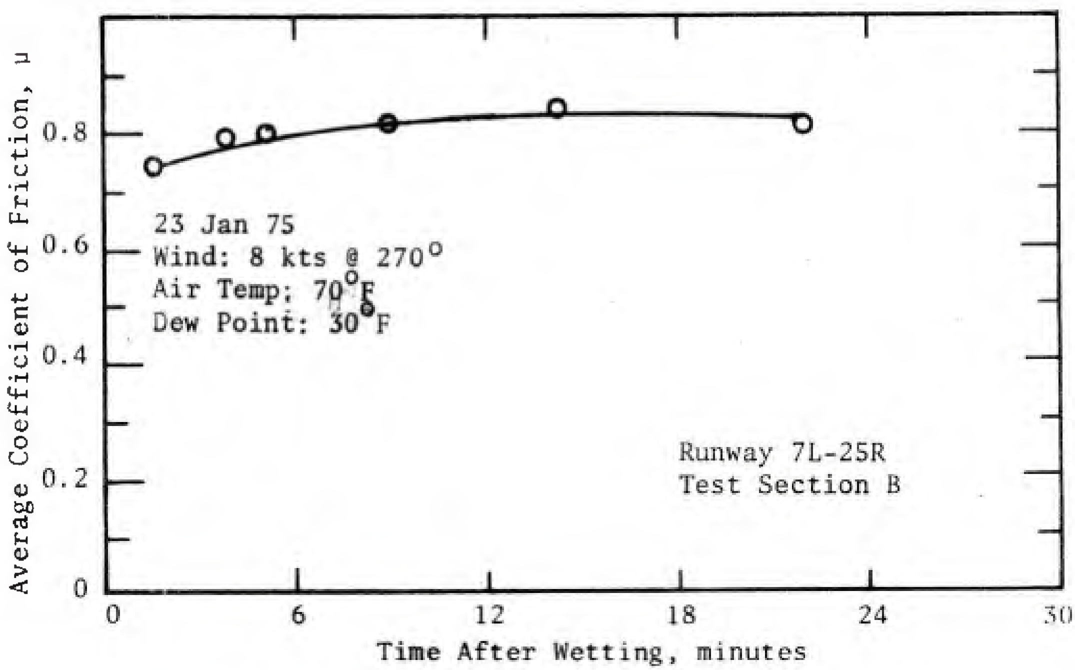
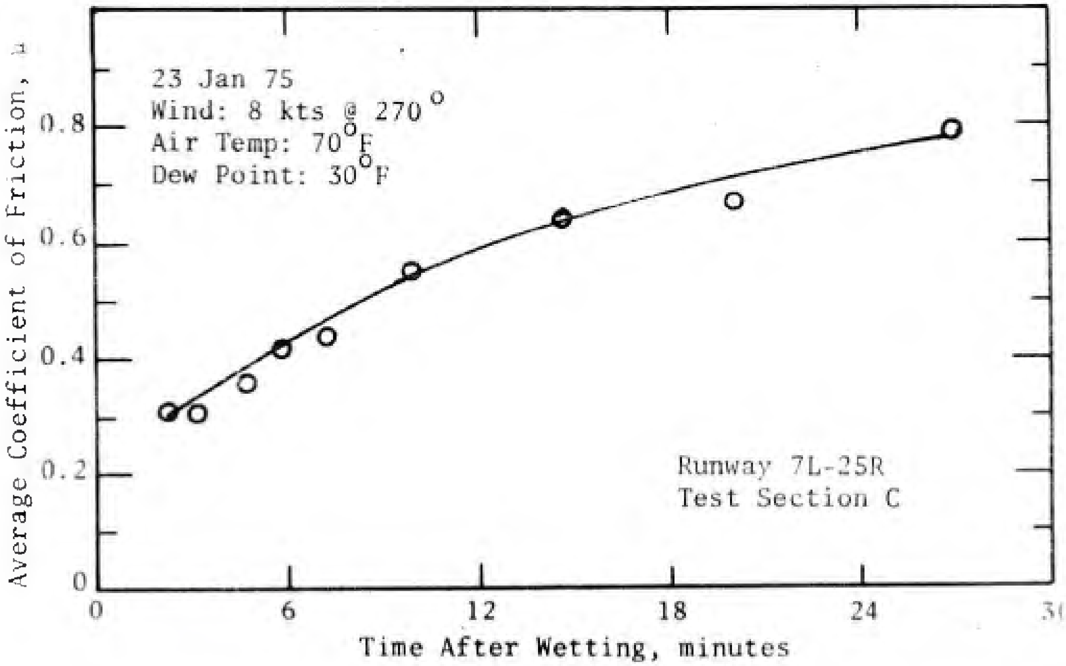


Figure 15 . Average Friction Coefficient versus Time After Wetting, USMCAS El Toro, CA



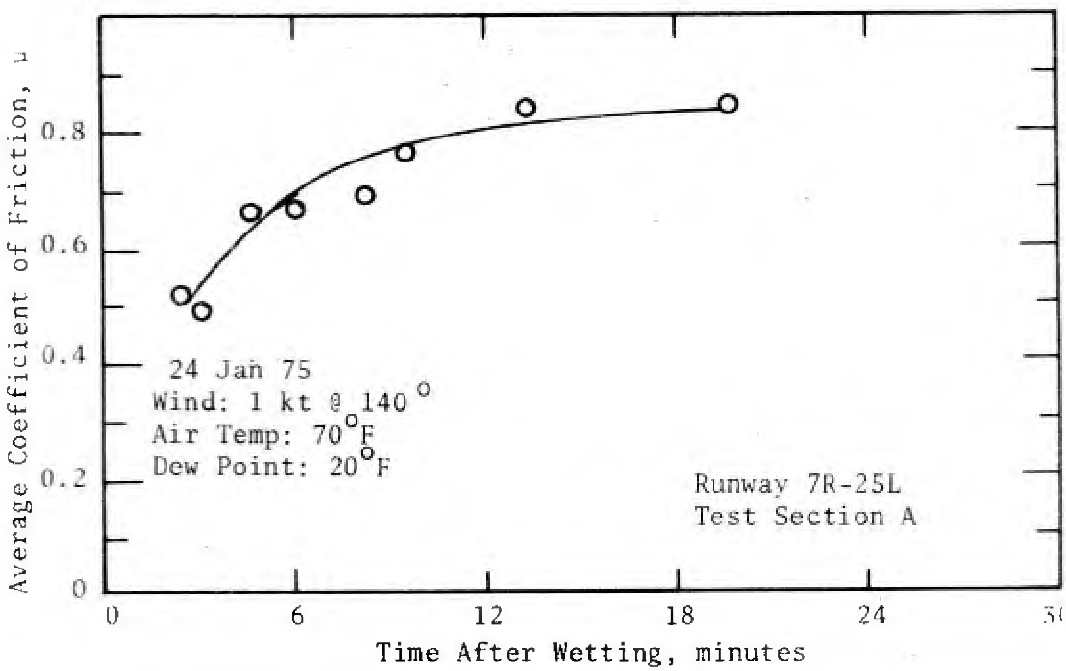
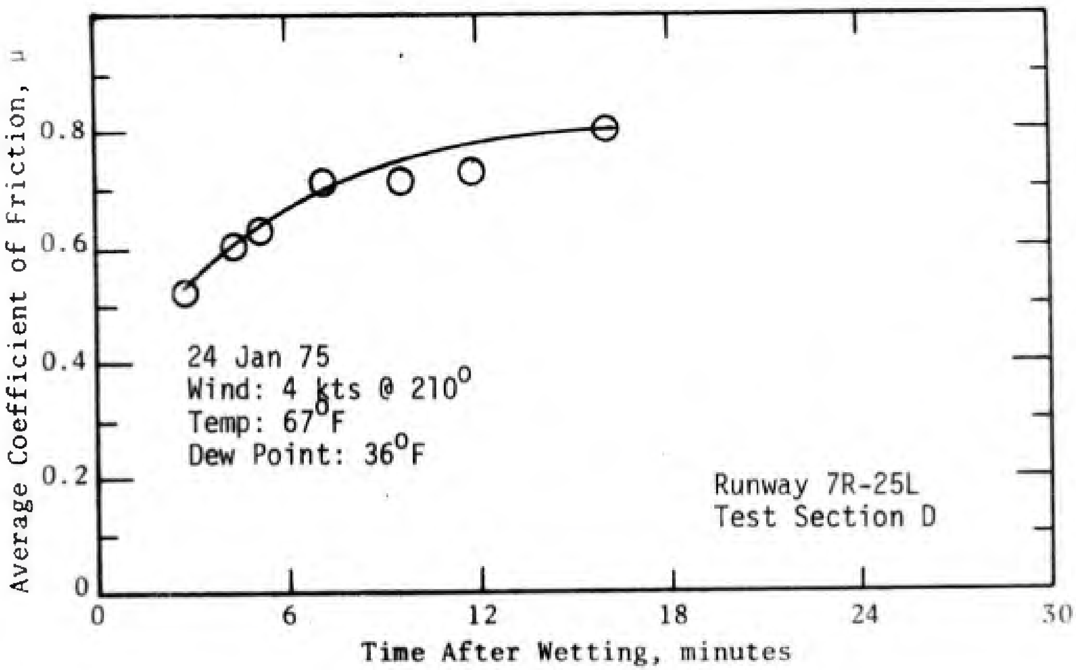


Figure 16 . Average Friction Coefficient versus Time After Wetting, USMCAS El Toro, CA



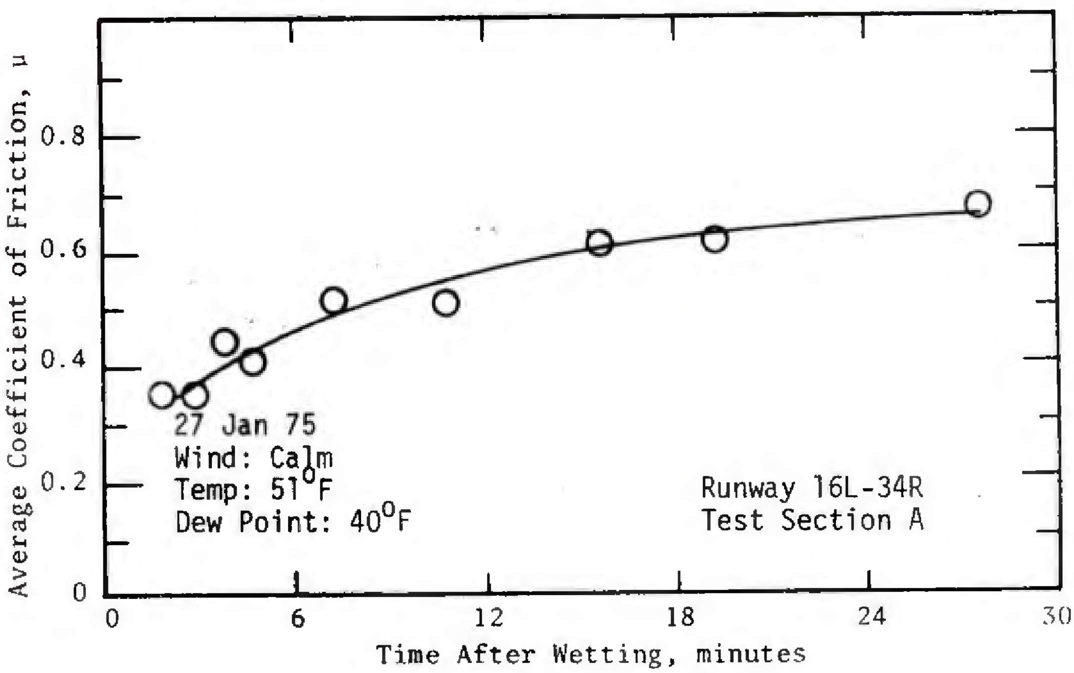
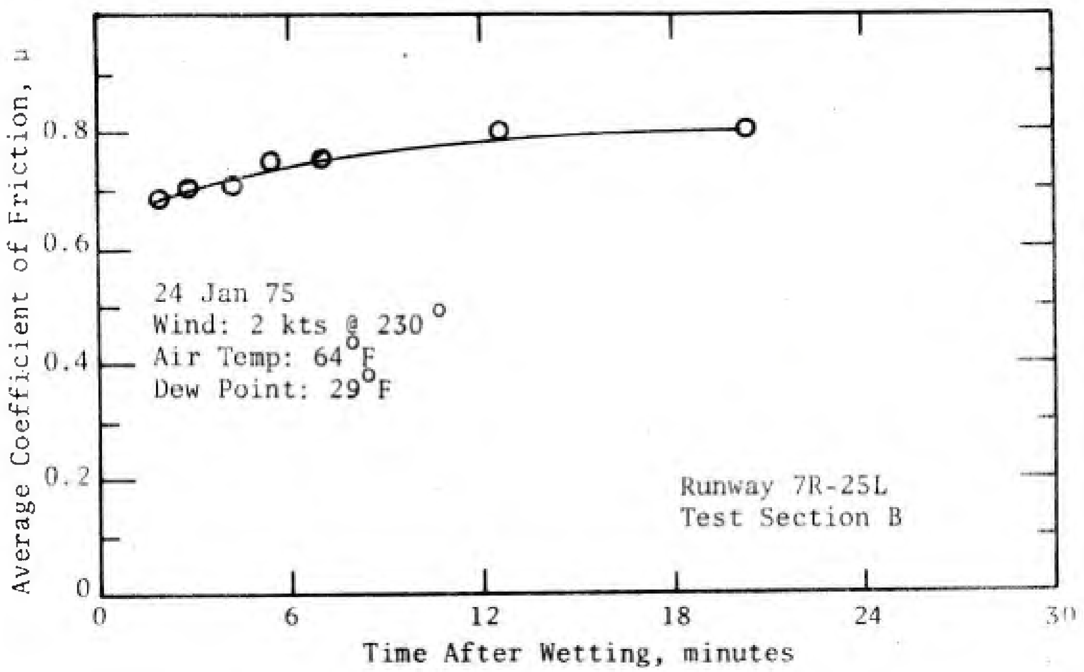


Figure 18. Average Friction Coefficient versus Time AFter Wetting, USMCAS El Toro, CA



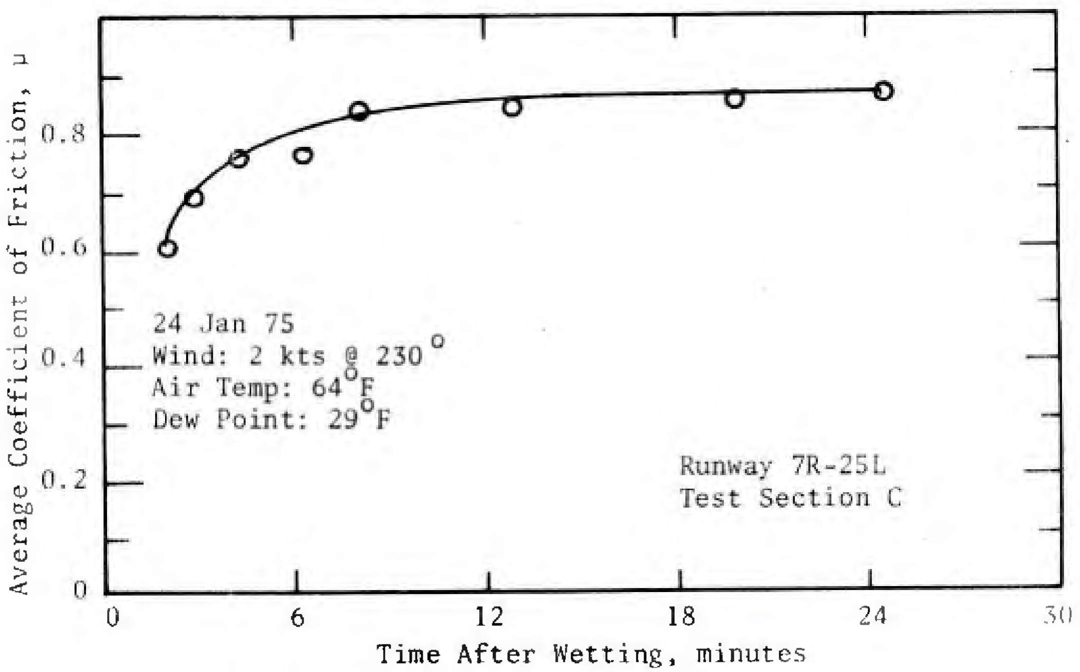
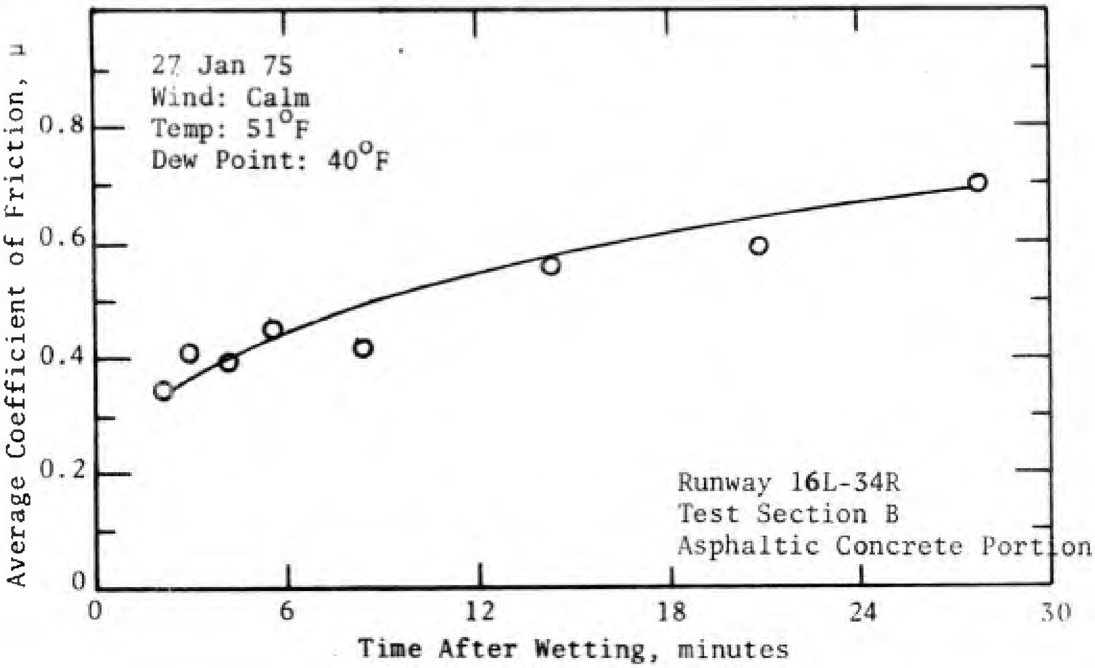


Figure 17. Average Friction Coefficient versus Time After Wetting, USMCAS El Toro, CA



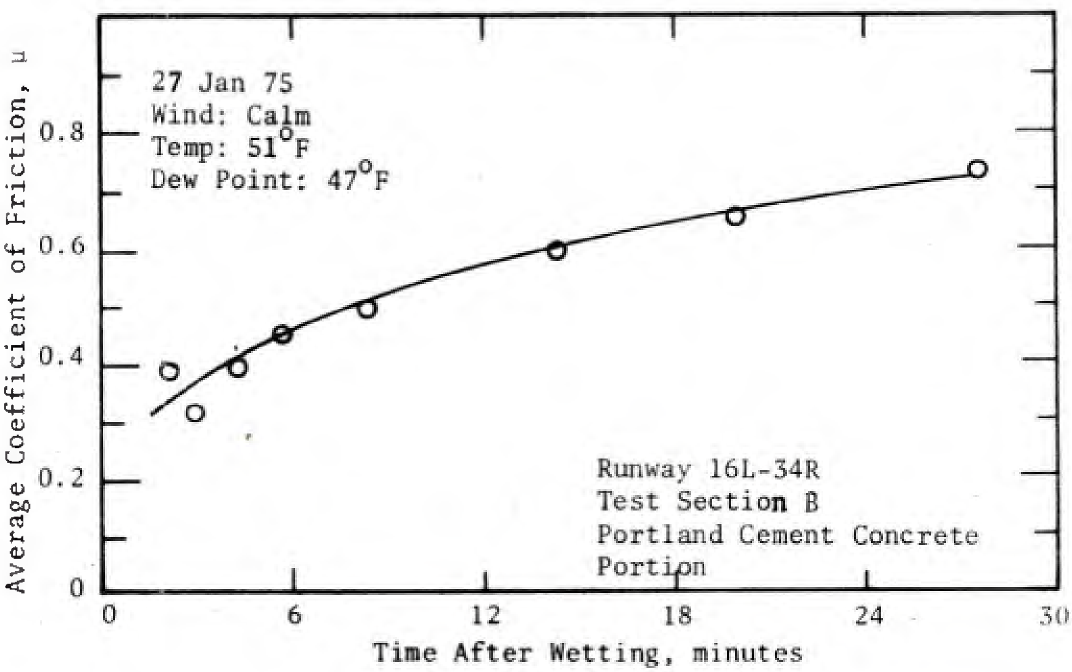
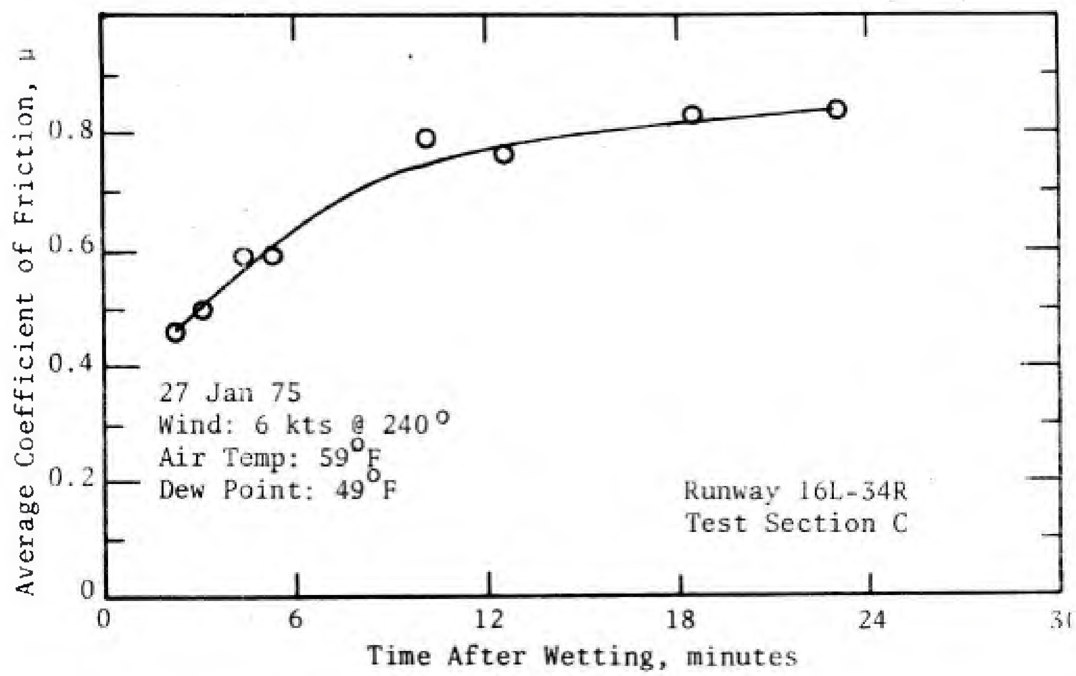


Figure 19. Average Friction Coefficient versus Time After Wetting USMCAS El Toro, CA



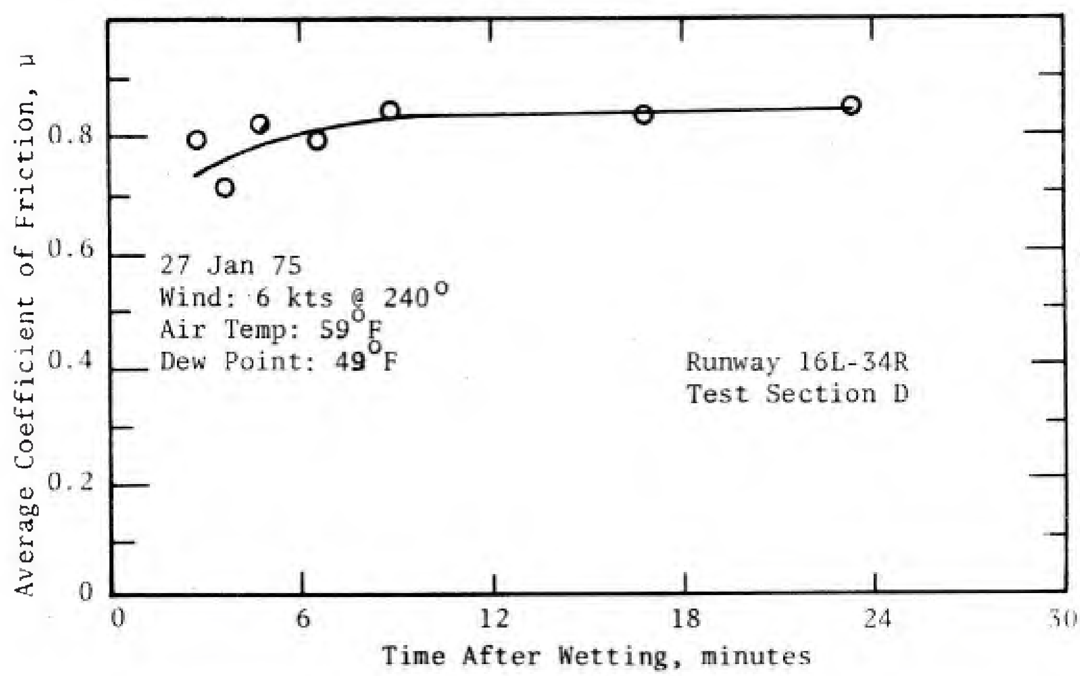


Figure 20. Average Friction Coefficient versus Time After Wetting, USMCAS El Toro, CA

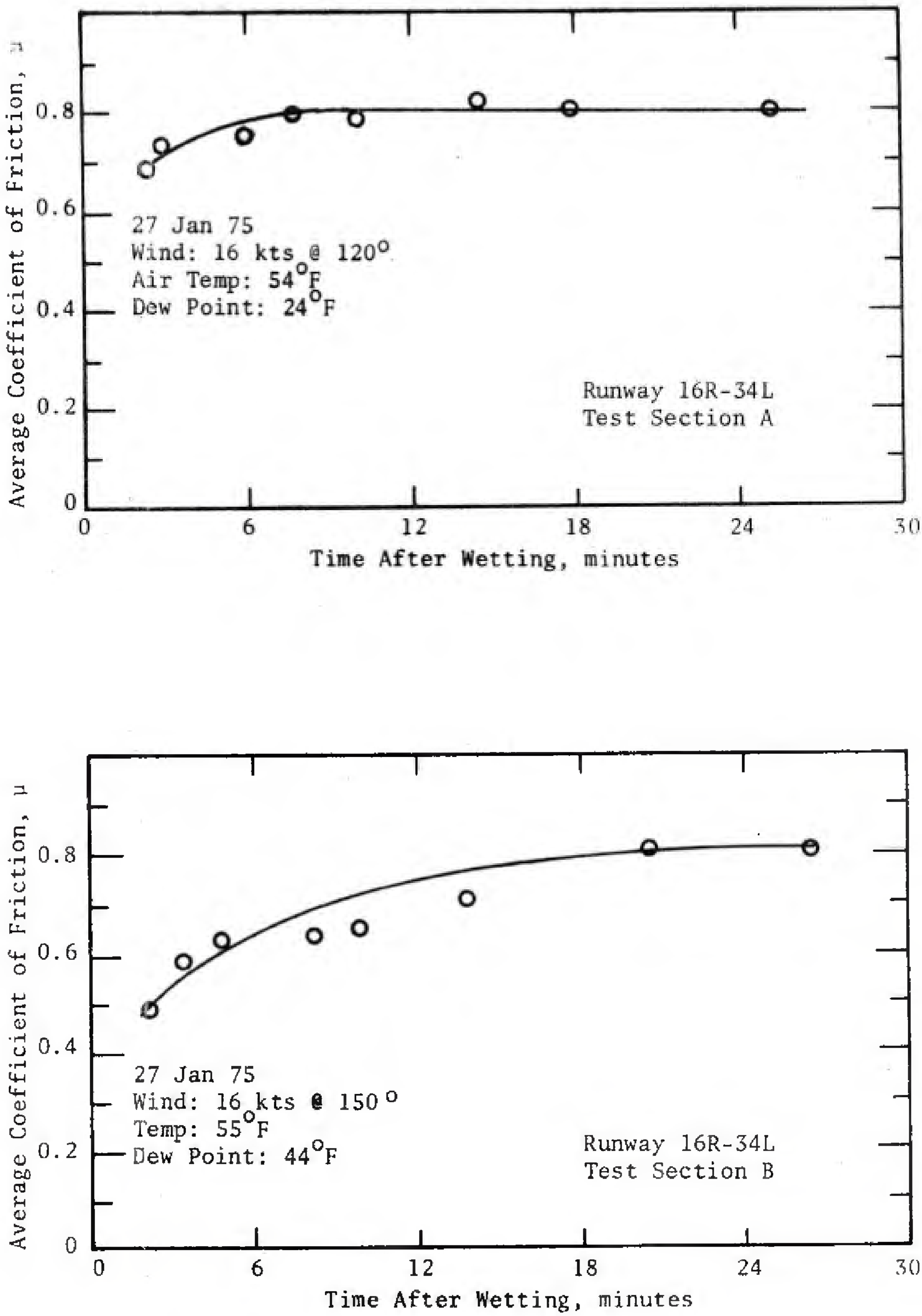
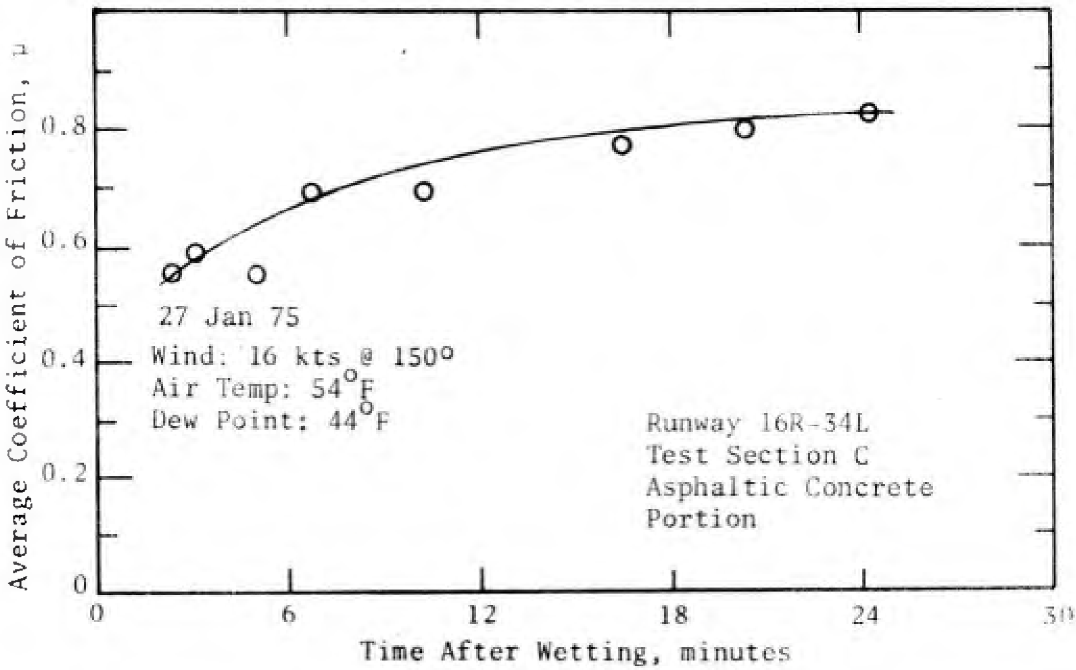


Figure 21. Average Friction Coefficient versus Time After Wetting, USMCAS El Toro, CA



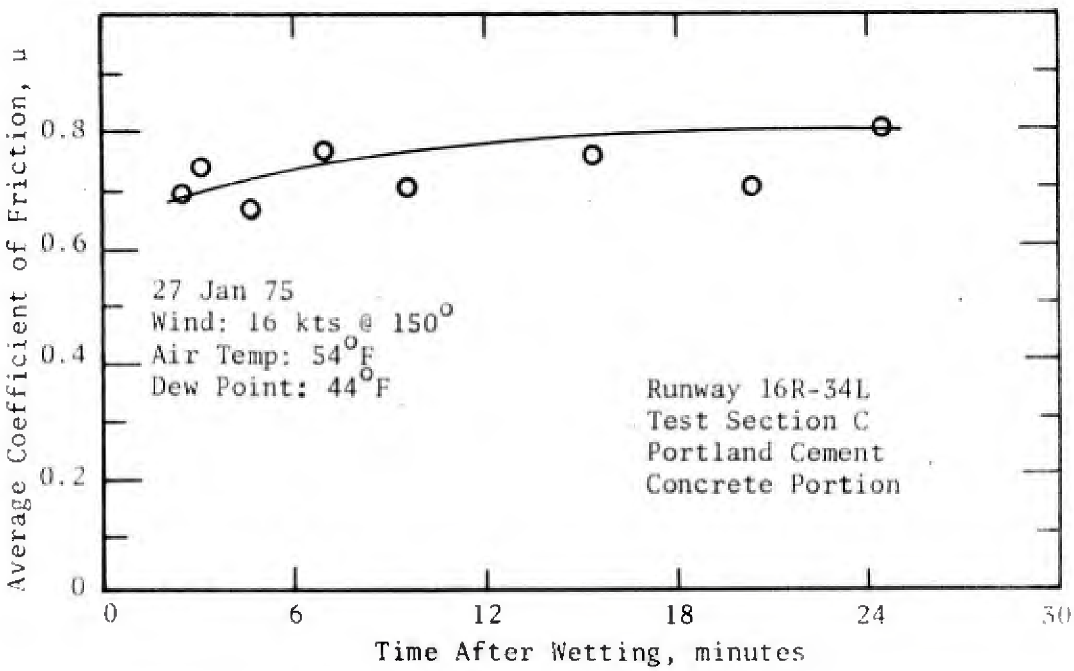
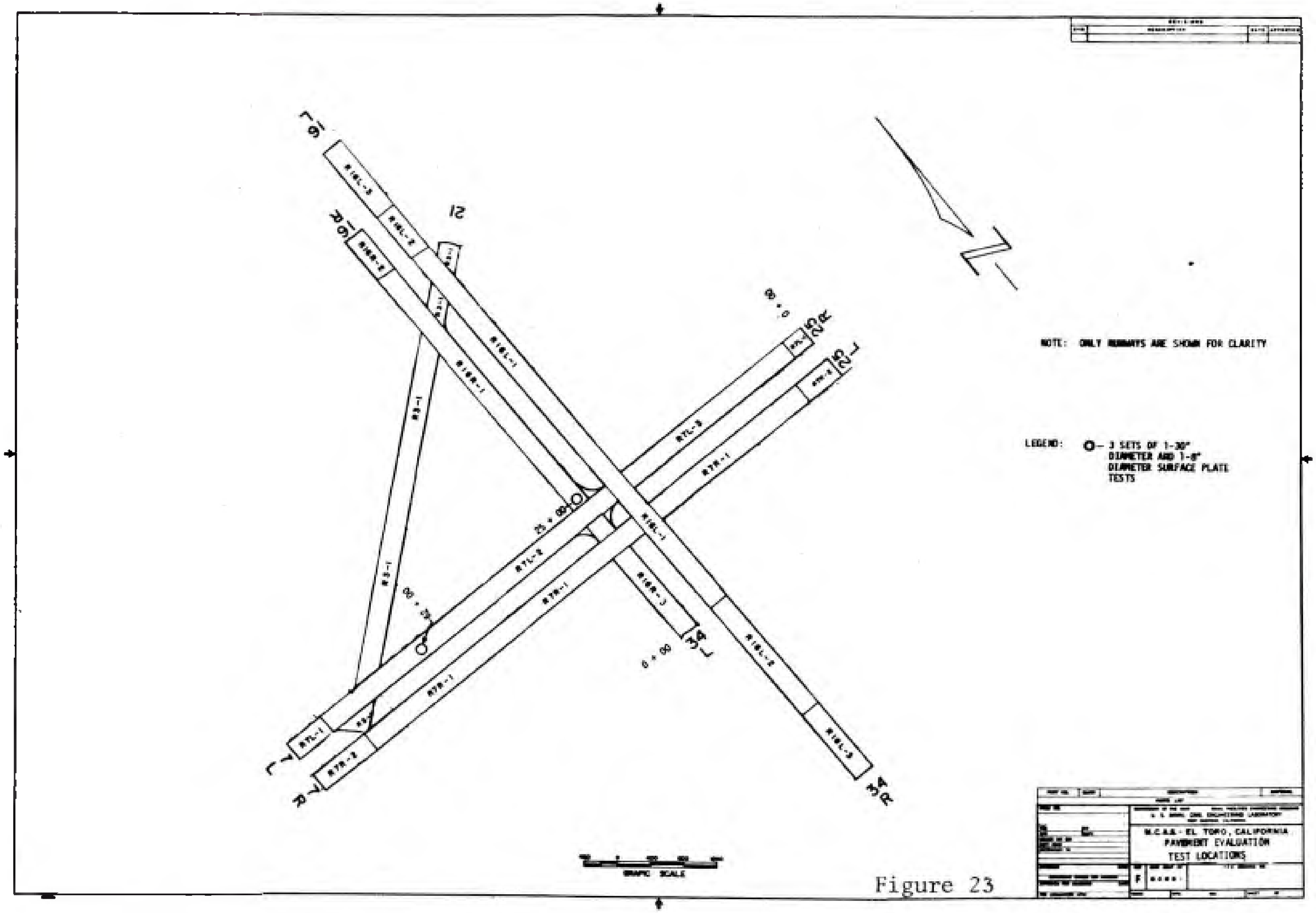


Figure 22. Average Friction Coefficient versus Time After Wetting, USMCAS El Toro, CA



NOTE: ONLY RUNWAYS ARE SHOWN FOR CLARITY
LEGEND: O— 3 SETS OF 1-30" DIAMETER AND 1-8" DIAMETER SURFACE PLATE TESTS
N.C.A.S. - EL TORO, CALIFORNIA
PAVEMENT EVALUATION
TEST LOCATIONS
GRAPHIC SCALE

Figure 23

ASPHALTIC CONCRETE

DISCRETE AREA DEFECT SUMMARY

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 3-21

Discrete Area R3-1 Area of Discrete Area (a) 470,000 ft^2

No. of Sample Areas (b) 13 Ratio: (a/2500b) 14.5

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects: (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density: (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ*	2,170 ft.	31,465 ft.	0.699	3.0	2.01
Reflection Crack					
Faulting					
Patching	880 $ft.^2$	12,670 $ft.^2$	0.270	3.5	0.95
Settlement or Depression					
Pattern Cracking	100 $ft.^2$	1,450 $ft.^2$	0.031	3.0	0.09
Rutting					
Raveling	4,272 $ft.^2$	61,944 $ft.^2$	1.318	7.0	9.23
Erosion—Jet Blast					
Oil Spillage					
Broken-up Area					
				Total	12.28A**

Remarks on Pavement Condition

Surface aggregate is completely exposed and devoid of bitumen. Cracks have some vegetation growing in them. Raveling was detected in the worst areas where loss of surface fines was noted. Almost the entire area could be considered to be in a state of incipient raveling. See Figure 3.

* Transverse crack, longitudinal crack or longitudinal construction joint crack.

** Letter suffix "A" indicates asphaltic pavement.

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 7R-25L

Discrete Area R7R-1 Area of Discrete Area (a) 650,000 ft^2

No. of Sample Areas (b) 16 Ratio: (a/2500b) 16.25

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ*	676 ft.	10,985 ft.	0.169	3.0	0.51
Reflection Crack	5,775 ft.	93,844 ft.	1.444	1.5	2.17
Faulting					
Patching					
Settlement or Depression					
Pattern Cracking	1,650 ft.^{2}	26,813 ft.^{2}	0.413	3.0	1.24
Rutting					
Raveling	8 ft.^{2}	130 ft.^{2}	0.002	7.0	0.01
Erosion–Jet Blast					
Oil Spillage					
Broken-up Area					
				Total	3.93A**

Remarks on Pavement Condition

Pattern cracking occurred along reflection cracks. Reflection cracks have been sealed and resealed. There is a large buildup of joint seal material on the pavement surface. See Figure 4.

* Transverse crack, longitudinal crack or longitudinal construction joint crack.

** Letter suffix "A" indicates asphaltic pavement.

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 7L-25R

Discrete Area R7L-2 Area of Discrete Area (a) 448,000 ft^2

No. of Sample Areas (b) 15 Ratio: (a/2500b) 12.0

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects: (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density: (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ*					
Reflection Crack					
Faulting					
Patching					
Settlement or Depression					
Pattern Cracking					
Rutting					
Raveling					
Erosion—Jet Blast					
Oil Spillage					
Broken-up Area					
				Total	0.00A**

Remarks on Pavement Condition

New pavement - no defects noted.

* Transverse crack, longitudinal crack or longitudinal construction joint crack.
** Letter suffix "A" indicates asphaltic pavement.

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 7L-25R

Discrete Area R7L-3 Area of Discrete Area (a) 250,000 ft^2

No. of Sample Areas (b) 15 Ratio: (a/2500b) 6.7

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects. (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ *	3,541 ft.	23,725 ft.	0.949	3.0	2.85
Reflection Crack					
Faulting					
Patching	40 ft.^{2}	268 ft.^{2}	0.011	3.5	0.04
Settlement or Depression					
Pattern Cracking	2,002 ft.^{2}	13,413 ft.^{2}	0.537	3.0	1.61
Rutting					
Raveling	3 ft.^{2}	20 ft.^{2}	0.001	7.0	0.01
Erosion – Jet Blast					
Oil Spillage					
Broken-up Area					
				Total	4.51A

Remarks on Pavement Condition

Tranverse and longitudinal cracks were mostly sealed. Most pattern cracking was fine hairline cracking. Some water percolates up through the longitudinal cracks and pattern cracking after rains.

* Transverse crack, longitudinal crack or longitudinal construction joint crack.

** Letter suffix "A" indicates asphaltic pavement.

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 16R-34L

Discrete Area R16R-1 Area of Discrete Area (a) 543,000 ft^2

No. of Sample Areas (b) 16 Ratio: (a/2500b) 13.6

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects: (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density: (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ *					
Reflection Crack					
Faulting					
Patching					
Settlement or Depression					
Pattern Cracking					
Rutting					
Raveling					
Erosion—Jet Blast					
Oil Spillage					
Broken-up Area					
				Total	0.00A **

Remarks on Pavement Condition

New pavement - no defects

* Transverse crack, longitudinal crack or longitudinal construction joint crack.
** Letter suffix "A" indicates asphaltic pavement.

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 16L-34R

Discrete Area R16L-1 Area of Discrete Area (a) 556,400 ft^2

No. of Sample Areas (b) 15 Ratio: (a/2500b) 14.8

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density: (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ*	343 ft.	5,076 ft.	0.091	3.0	0.27
Reflection Crack	5,150 ft.^{2}	76,220 ft.	1.370	1.5	2.06
Faulting					
Patching					
Settlement or Depression					
Pattern Cracking	3,217 ft.^{2}	47,612 ft.^{2}	0.856	3.0	2.57
Rutting					
Raveling	16 ft.^{2}	237 ft.^{2}	0.004	7.0	0.03
Erosion–Jet Blast	100 ft.^{2}	1,480 ft.^{2}	0.27	7.5	0.20
Oil Spillage					
Broken-up Area					
				Total	5.13A**

Remarks on Pavement Condition

Pattern cracking occurs along reflection cracks. See Figure 5.

* Transverse crack, longitudinal crack or longitudinal construction joint crack.

** Letter suffix "A" indicates asphaltic pavement.

PORTLAND CEMENT CONCRETE

DISCRETE AREA DEFECT SUMMARY

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 3-21

Discrete Area R3-2 Total Slabs in Discrete Area (a) 64

No. of Slabs Sampled (b) 16 Ratio a/b = 4

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling	2	8	0.125	7.5	0.94
Scaling					
Shattered Slab					
Joint Seal	13	52	0.813	3.0	2.48
Pumping					
"D-line" cracking					
				Total	3.42C***

Remarks on Pavement Condition

Vegetation was observed growing through joints.

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 7R-25L

Discrete Area R7R-2 Total Slabs in Discrete Area (a) 710

No. of Slabs Sampled (b) 178 Ratio a/b = 4

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling	26	104	0.146	7.5	1.10
Scaling					
Shattered Slab					
Joint Seal	96	384	0.541	3.0	1.62
Pumping					
"D-line" cracking					
				Total	2.72C***

Remarks on Pavement Condition

Joint seal was shrunken and hardened. Spalls were up to 2"x10" and some corner spalls had 3" to 4" legs on corners. After rainfall some percolation of water from pavement joints was observed at both ends of the runway. See Figure 6.

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 7L-25R

Discrete Area R7L-1 Total Slabs in Discrete Area (a) 424

No. of Slabs Sampled (b) 106 Ratio a/b = 4

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling	19	76	0.179	7.5	1.34
Scaling	2	8	0.019	7.0	0.13
Shattered Slab					
Joint Seal	38	152	0.358	3.0	1.07
Pumping					
"D-line" cracking					
				Total	3.54C***

Remarks on Pavement Condition

Some spalls as large as 2" by 10" were noted. Some corner spalls with concrete missing were as deep as 3 inches.

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 16R-34L

Discrete Area R16R-2 Total Slabs in Discrete Area (a) 344

No. of Slabs Sampled (b) 86 Ratio a/b = 4

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling	1	4	0.011	7.5	0.08
Scaling					
Shattered Slab					
Joint Seal	10	40	0.116	3.0	0.35
Pumping					
"D-line" cracking					
				Total	0.43C***

Remarks on Pavement Condition

Joint seal was generally in good condition. Defects noted consisted of vegetation growing through joints.

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 16L-34R

Discrete Area R16L-2 Total Slabs in Discrete Area (a) 1320

No. of Slabs Sampled (b) 165 Ratio a/b = 8

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling	24	192	0.145	7.5	1.09
Scaling					
Shattered Slab					
Joint Seal	59	472	0.358	3.0	1.07
Pumping					
"D-line" cracking					
				Total	2.16C ***

Remarks on Pavement Condition

Spalls generally ranged in size from 2" by 8" to 2" by 10". Joint seal was dried up and separated from the concrete. Some areas were almost devoid of joint seal.

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 16L-34R

Discrete Area R16L-3 Total Slabs in Discrete Area (a) 1607

No. of Slabs Sampled (b) 178 Ratio a/b = 9

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling	8	72	0.045	7.5	0.34
Scaling					
Shattered Slab					
Joint Seal	89	801	0.498	3.0	1.49
Pumping					
"D-line" cracking					
				Total	1.83C***

Remarks on Pavement Condition

Some spalls were as large as 2"x10". Vegetation was noted growing through joints. Joint seal was hardened and separated from the concrete.

* Longitudinal crack or Transverse crack

** Intersecting crack

*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USMCAS El Toro Facility Runway 16R-34L

Discrete Area R16R-3 Total Slabs in Discrete Area (a) 776

No. of Slabs Sampled (b) 154 Ratio a/b = 5

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling					
Scaling					
Shattered Slab					
Joint Seal					
Pumping					
"D-line" cracking					
				Total	0.00C***

Remarks on Pavement Condition

New pavement - no defects noted.

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

ASPHALTIC CONCRETE

FACILITY DEFECT SUMMARY

ASPHALTIC CONCRETE FACILITY DEFECT SUMMARY

Airfield USMCAS El Toro

Date Surveyed February 1975

Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Runway 3-21			
R3-1	12.28A	1.00	12.28A
Runway 7R-25L			
R7R-1	3.93A	1.00	3.93A
Runway 7L-25R			
R7L-2	0.00A	0.64	0.00
R7L-3	4.51A	0.36	1.62
			1.62A(Total)
Runway 16R-34L			
R16R-1	0.00A	1.00	0.00A
Runway 16L-34R			
R16L-1	5.13A	1.00	5.13A

* If facility entirely constructed of AC, indicates total facility area. If facility only partly constructed of AC, indicates total area of AC portion of facility.

** Letter suffix "A" on weighted defect densities indicates asphaltic concrete pavements.

ASPHALTIC CONCRETE FACILITY DEFECT SUMMARY

Airfield USMCAS El Toro

Date Surveyed July 1969 (Previous report)

Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Runway 3-21 R3-1	8.40	1.00	8.40A
Runway 7R-25L R7R-1	2.27A	1.00	2.27A
Runway 7L-25R R7L-2 R7L-3	5.94A 2.74A	0.63 0.38	3.74 1.04 4.78A(Total)
Runway 16R-34L R16R-1	9.03A	1.00	9.03A
Runway 16L-34R R16L-1	2.97A	1.00	2.97A

* If facility entirely constructed of AC, indicates total facility area. If facility only partly constructed of AC, indicates total area of AC portion of facility.

** Letter suffix "A" on weighted defect densities indicates asphaltic concrete pavements.

PORTLAND CEMENT CONCRETE

FACILITY DEFECT SUMMARY

PORTLAND CEMENT CONCRETE FACILITY DEFECT SUMMARY

Airfield USMCAS El Toro

Date Surveyed February 1975

Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Runway 3-21			
R3-2	3.42C	1.00	3.42C
Runway 7R-25L			
R7R-2	2.72C	1.00	2.72C
Runway 7L-25R			
R7L-1	3.54C	1.00	3.54C
Runway 16R-34L			
R16R-2	0.43C	0.31	0.13
R16R-3	0.00C	0.69	0.00
			0.13C(Total)
Runway 16L-34R			
R16L-2	2.16C	0.45	0.97
R16L-3	1.83C	0.55	1.01
			1.98C(Total)

* If facility entirely constructed of PCC, indicates total facility area. If facility only partly constructed of PCC, indicates total area of PCC portion of facility.

** Letter suffix "C" on weighted defect densities indicates Portland cement concrete pavements.

PORTLAND CEMENT CONCRETE FACILITY DEFECT SUMMARY

Airfield USMCAS El Toro

Date Surveyed July 1969 (previous report)

Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Runway 3-21			
R3-2	3.28C	1.00	3.28C
Runway 7R-25L			
R7R-2	5.44C	1.00	5.44C
Runway 7L-25R			
R7L-1	3.71C	1.00	3.71C
Runway 16R-34L			
R16R-2	3.03C	1.00	3.03C
Runway 16L-34R			
R16L-2	3.18C	0.45	1.43
R16L-3	3.22C	0.55	1.77
			3.20C (Total)

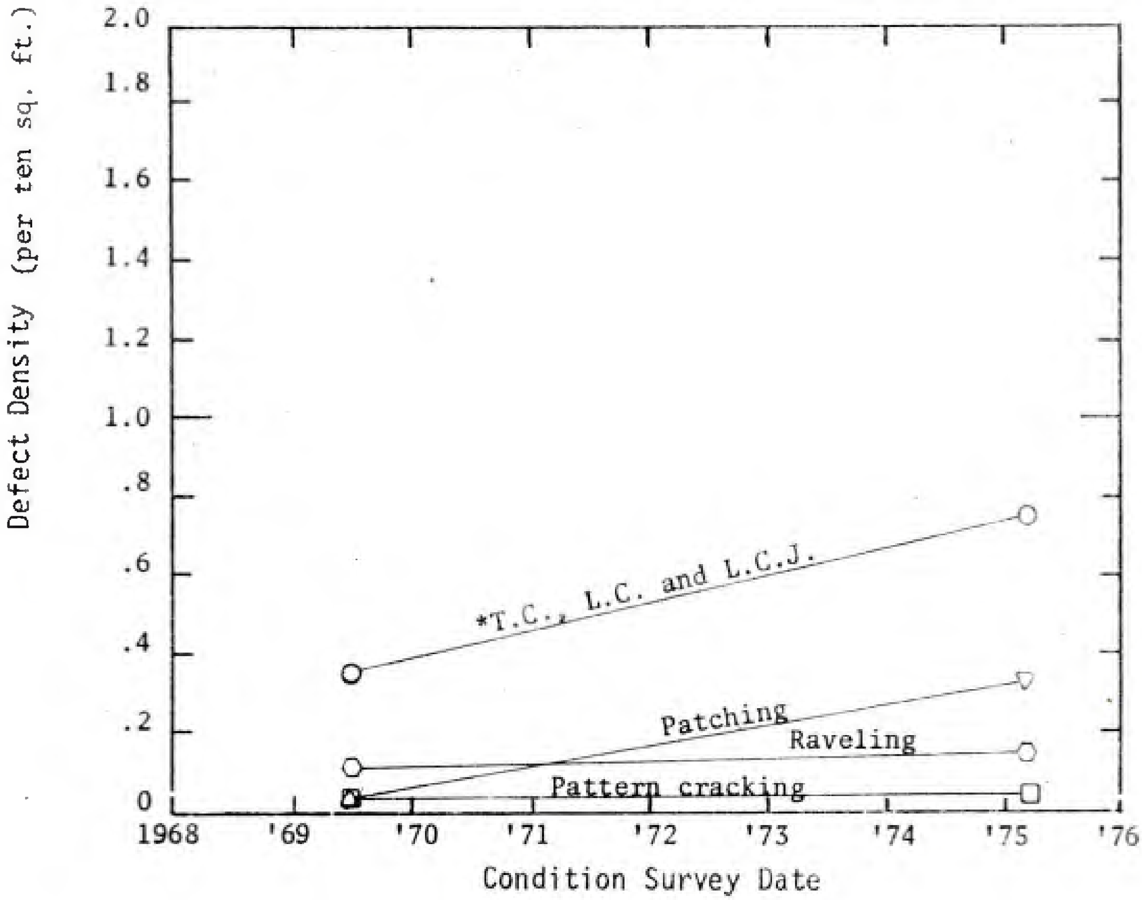
* If facility entirely constructed of PCC, indicates total facility area. If facility only partly constructed of PCC, indicates total area of PCC portion of facility.

** Letter suffix "C" on weighted defect densities indicates Portland cement concrete pavements.

DISCRETE AREA

CONDITION ANALYSIS

DISCRETE AREA CONDITION ANALYSIS



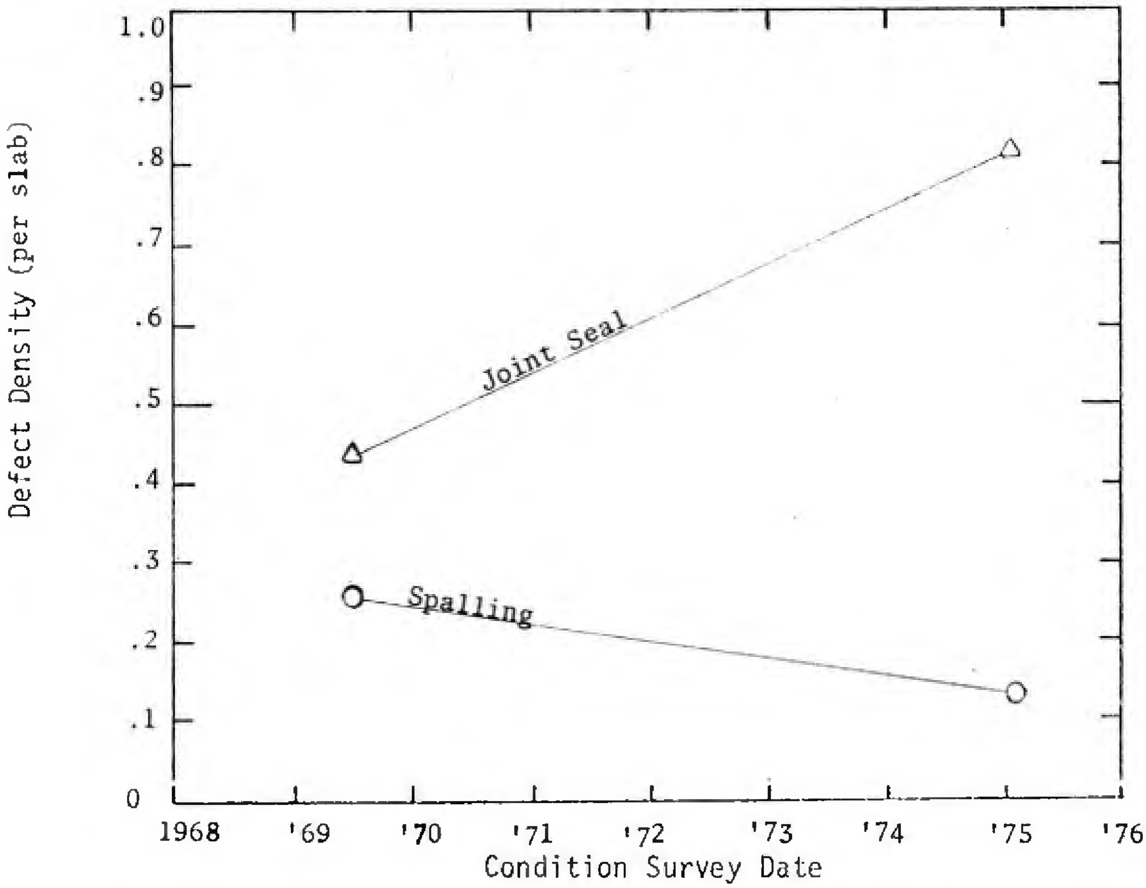
Airfield USMCAS El Toro	Facility Runway 3-21
Discrete Area R3-1	Pavement Type AC

Discussion

It appears that the number of longitudinal, transverse and longitudinal construction joint cracks have increased with time. Additional patching has been performed by Public Works maintenance forces. The quantities of raveling and pattern cracking appear not to have changed significantly.

* Transverse crack, longitudinal crack and longitudinal construction joint crack

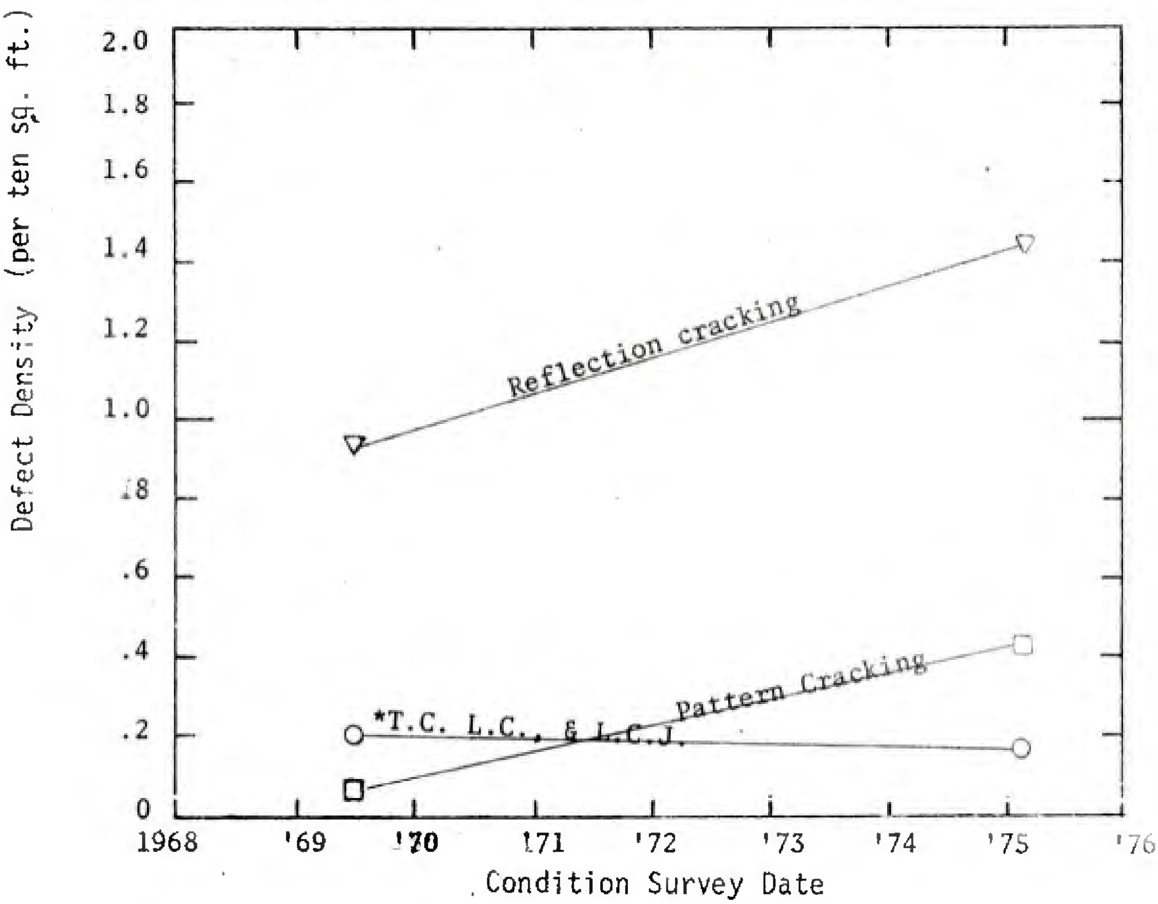
DISCRETE AREA CONDITION ANALYSIS



Airfield USMCAS El Toro Facility Runway 3-21
Discrete Area R3-2 Pavement Type PCC
Discussion

Spall repairs have been performed by station forces on a continuing basis. Joint seal exhibits normal increase in defect density with age.

DISCRETE AREA CONDITION ANALYSIS



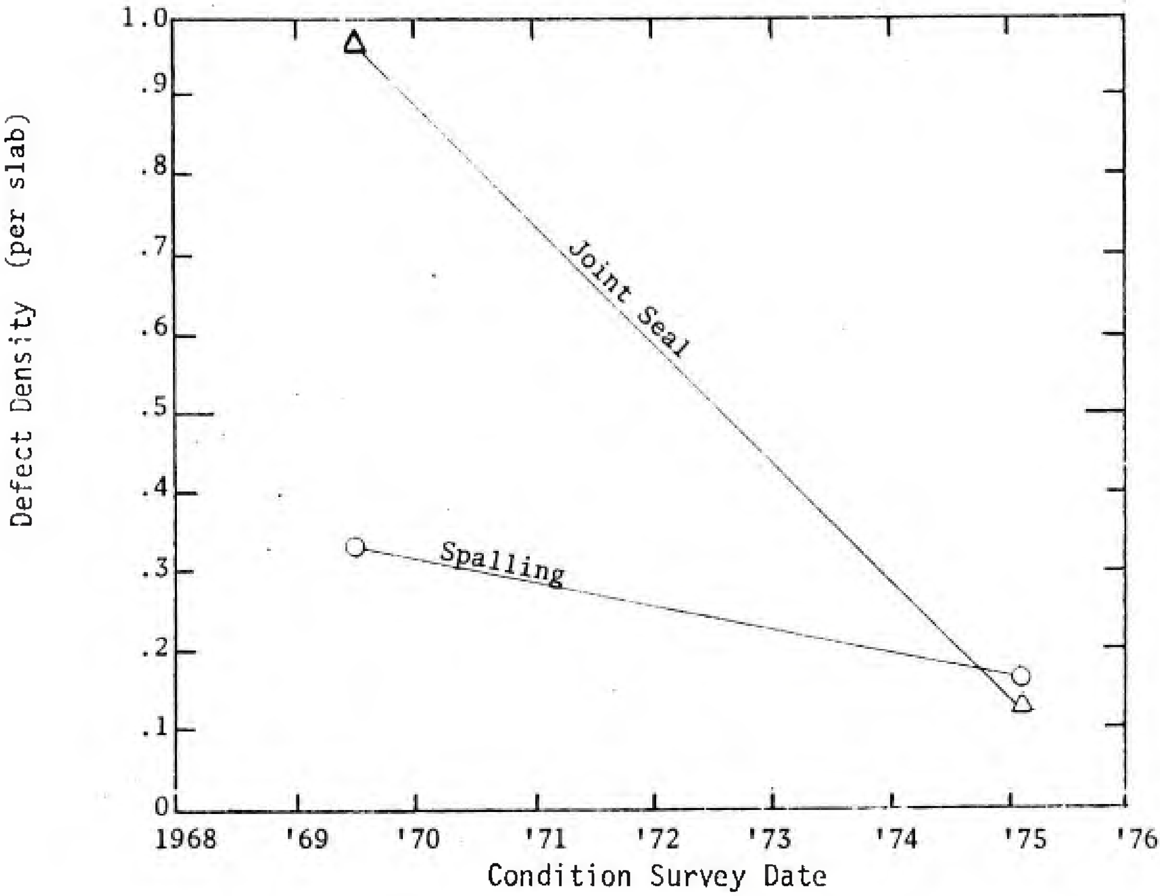
Airfield USMCAS El Toro Facility Runway 7R-25L
Discrete Area R7R-1 Pavement Type A.C.

Discussion

Transverse and longitudinal cracks appear not to have changed density. Some previously designated transverse and longitudinal cracks could have developed into pattern cracking.

* Transverse crack, longitudinal crack and longitudinal construction joint crack.

DISCRETE AREA CONDITION ANALYSIS



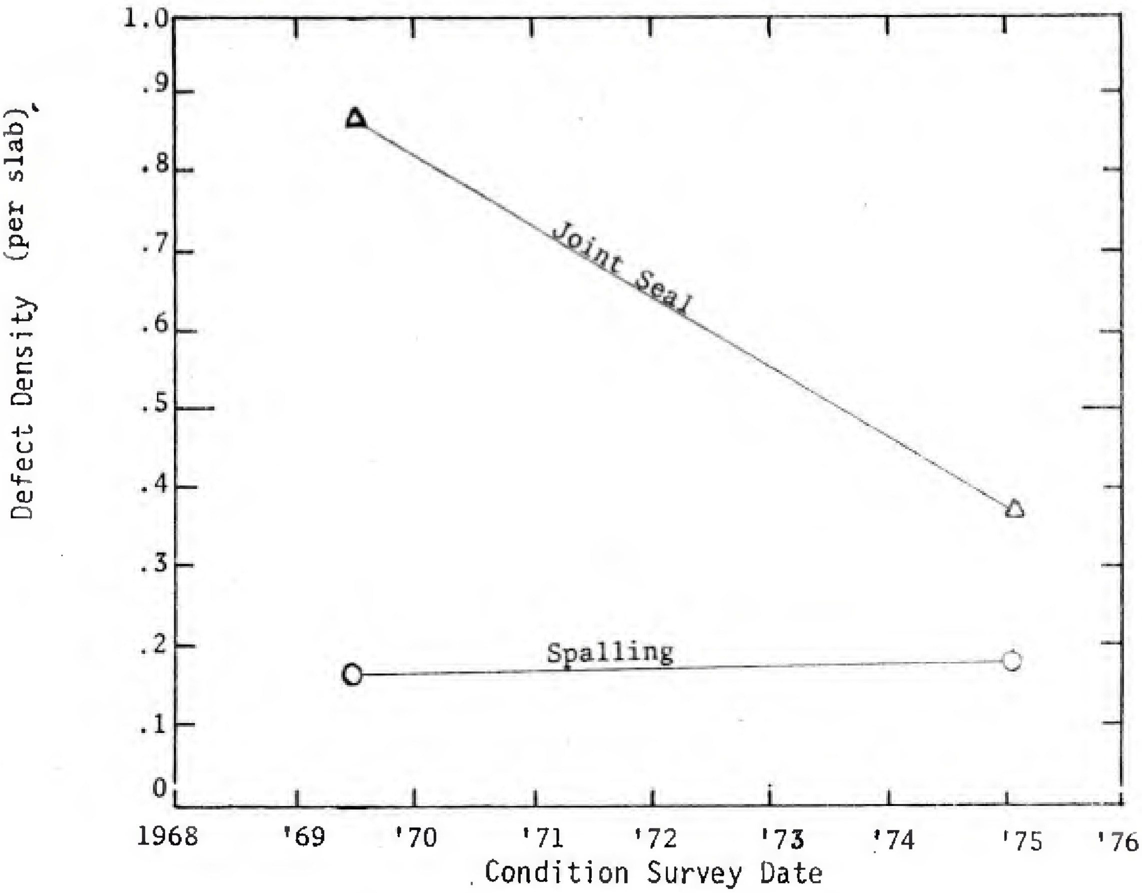
Airfield USMCAS El Toro Facility Runway 7R-25L

Discrete Area R7R-2 Pavement Type PCC

Discussion

Both joint seal removal and replacement and spall repairs have been accomplished on this pavement area since the previous condition survey.

DISCRETE AREA CONDITION ANALYSIS



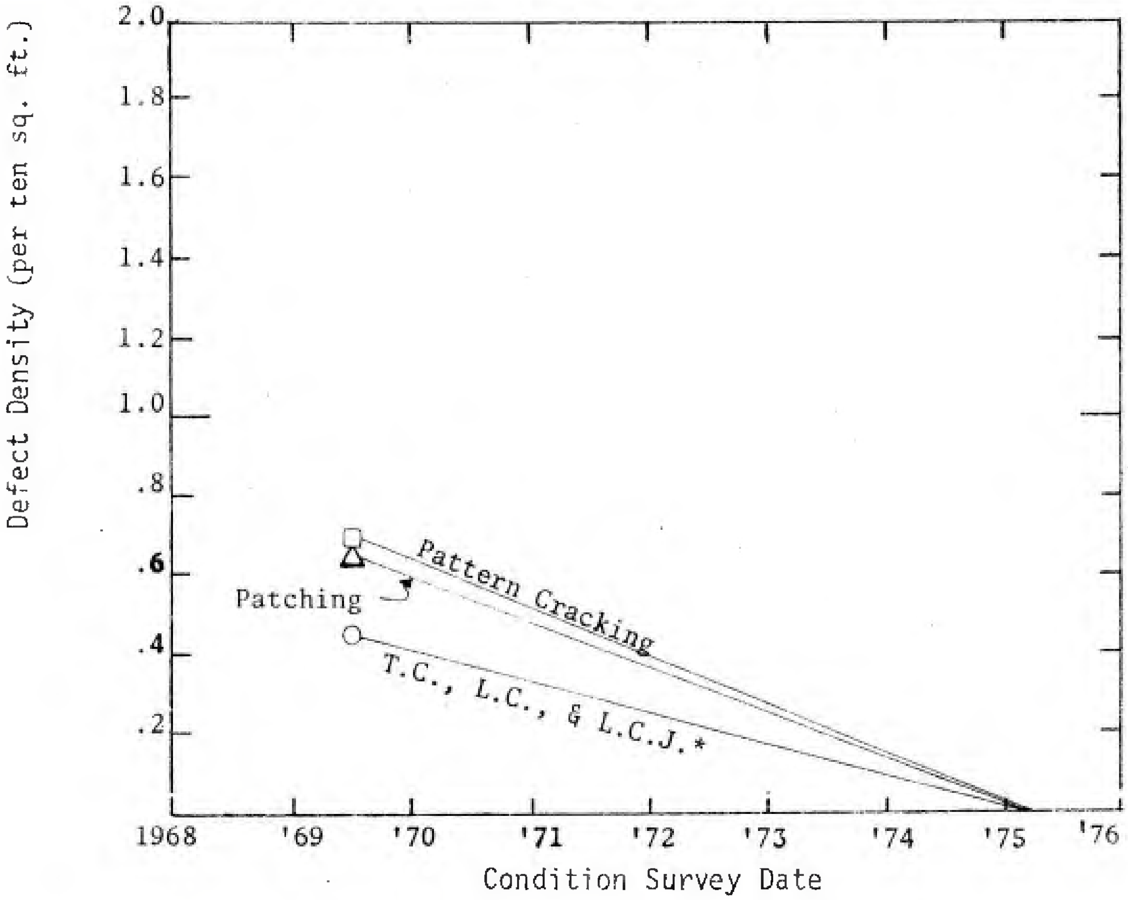
Airfield USMCAS El Toro　　Facility Runway 7L-25R

Discrete Area R7L-1　　Pavement Type PCC

Discussion

Spalling density appears to be essentially unchanged. Joint seal defect density has been lowered due to removal and replacement of bad joint seal by maintenance crew.

DISCRETE AREA CONDITION ANALYSIS

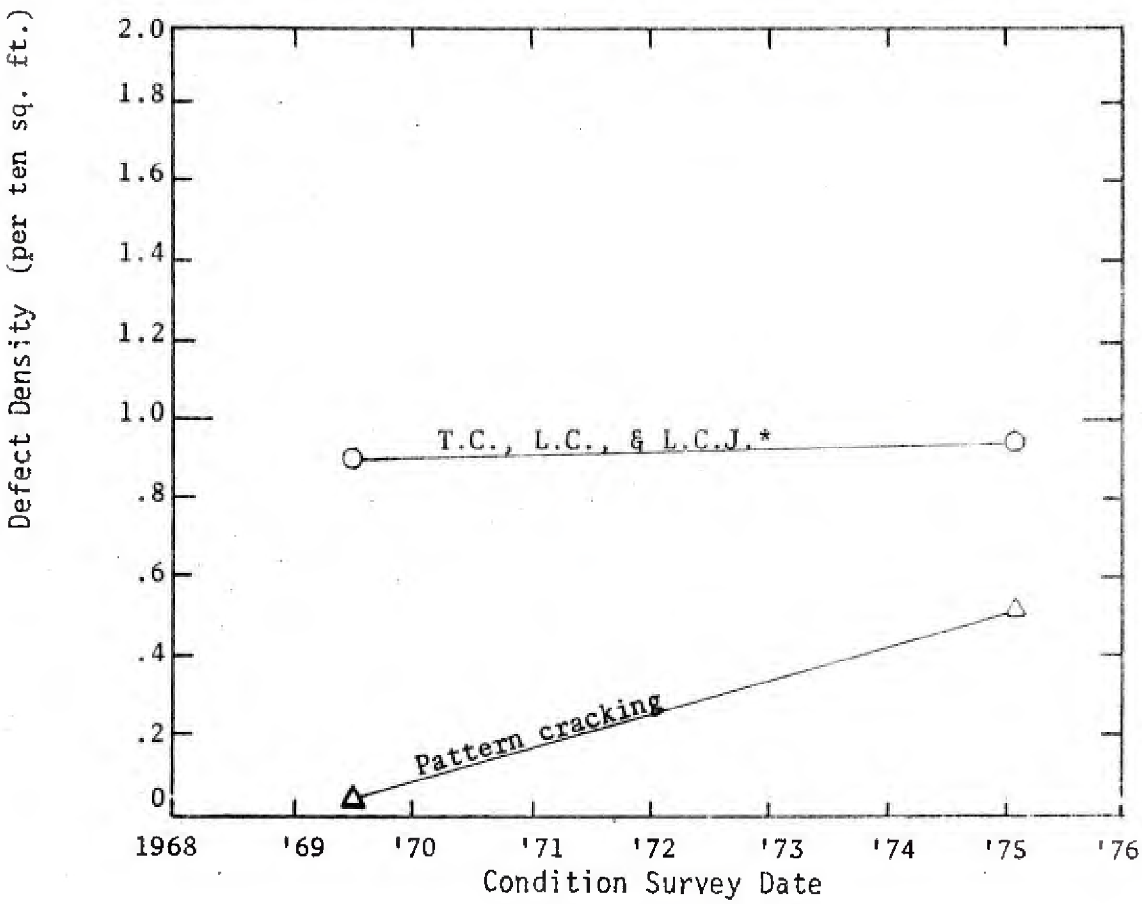


Airfield USMCAS El Toro, CA Facility Runway 7L-25R
Discrete Area R7L-2 Pavement Type A.C.
Discussion

This section of pavement has been rebuilt since the last condition survey.

*Transverse crack, longitudinal crack and longitudinal construction joint crack.

DISCRETE AREA CONDITION ANALYSIS

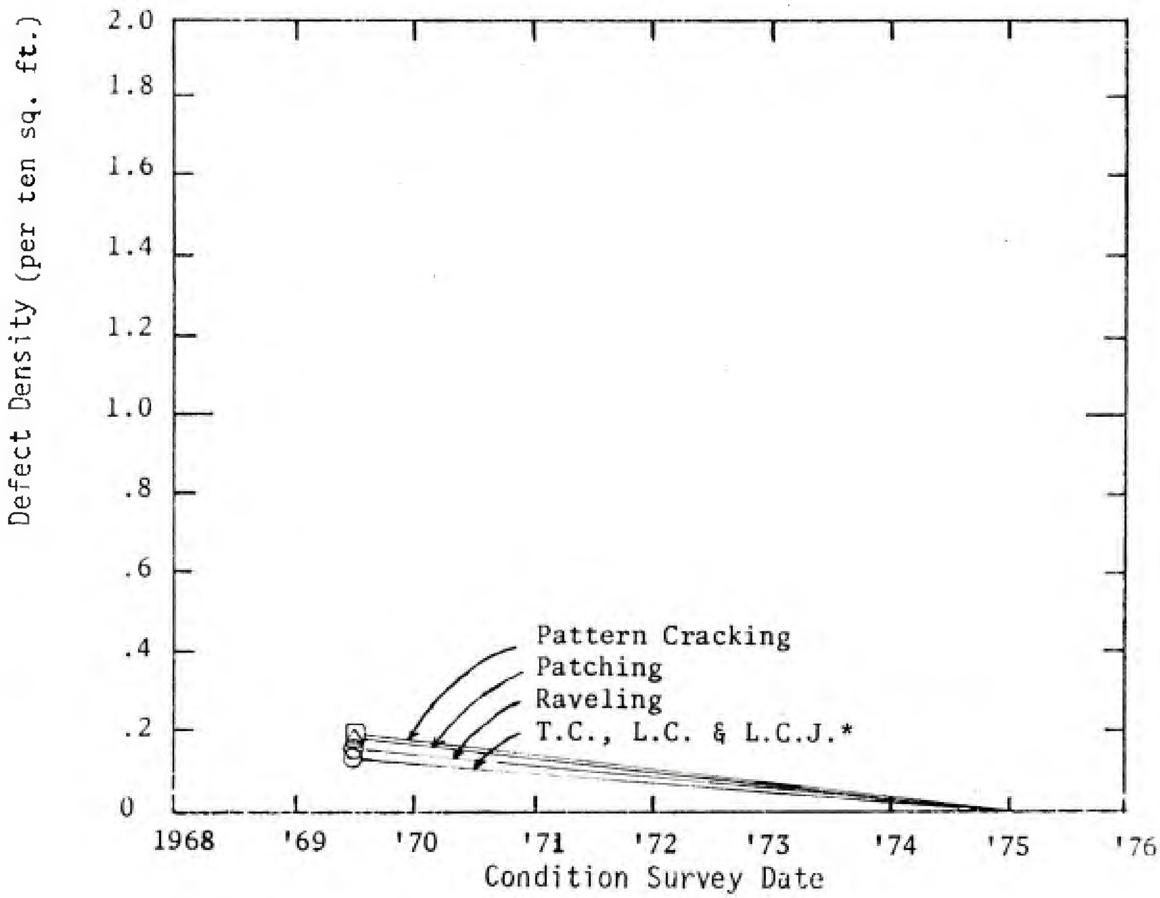


Airfield USMCAS El Toro Facility Runway 7L-25R
Discrete Area R7L-3 Pavement Type A.C.
Discussion

Pattern cracking increase consisted of fine hairline cracks. Other cracks did not appear to increase significantly.

*Transverse crack, longitudinal crack and longitudinal construction joint crack.

DISCRETE AREA CONDITION ANALYSIS

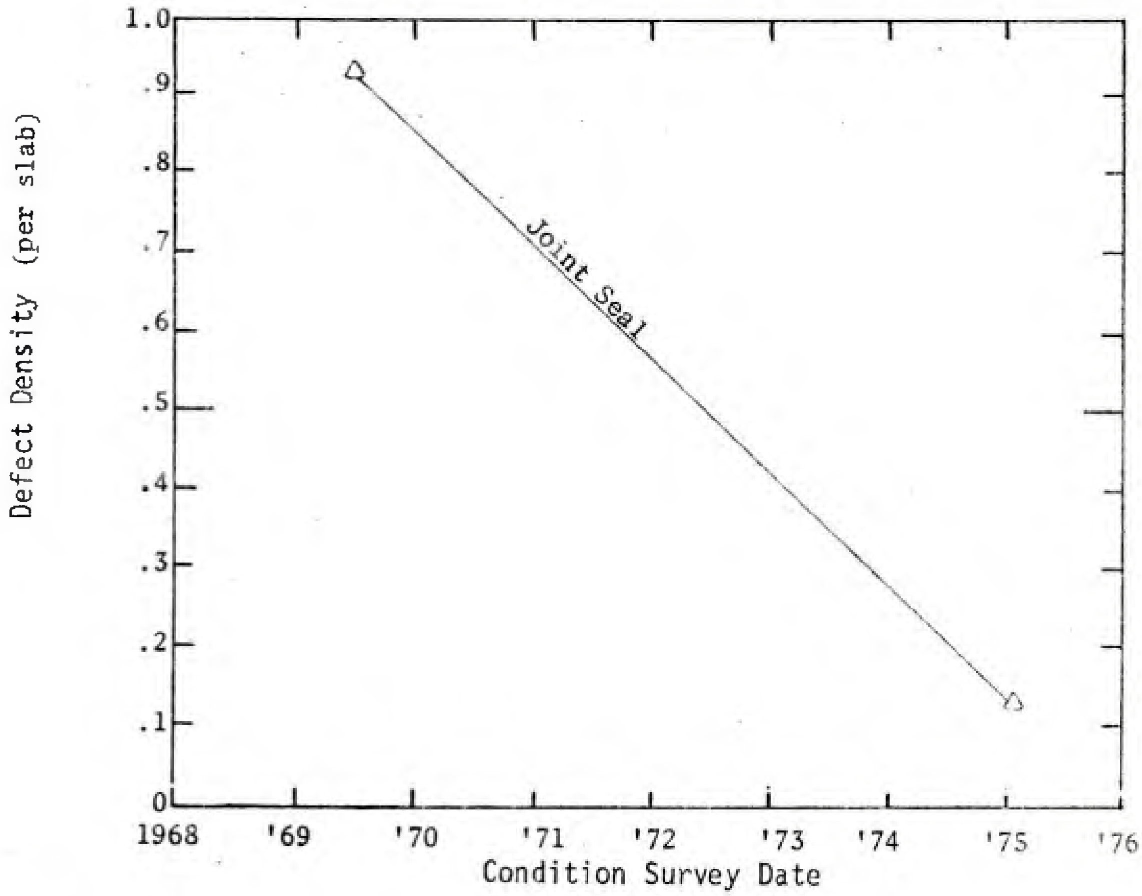


Airfield USMCAS El Toro Facility Runway 16R-34L
Discrete Area R16R-1 Pavement Type A.C.
Discussion

This area has been rebuilt since the last condition survey.

*Transverse crack, longitudinal crack and longitudinal construction joint crack.

DISCRETE AREA CONDITION ANALYSIS



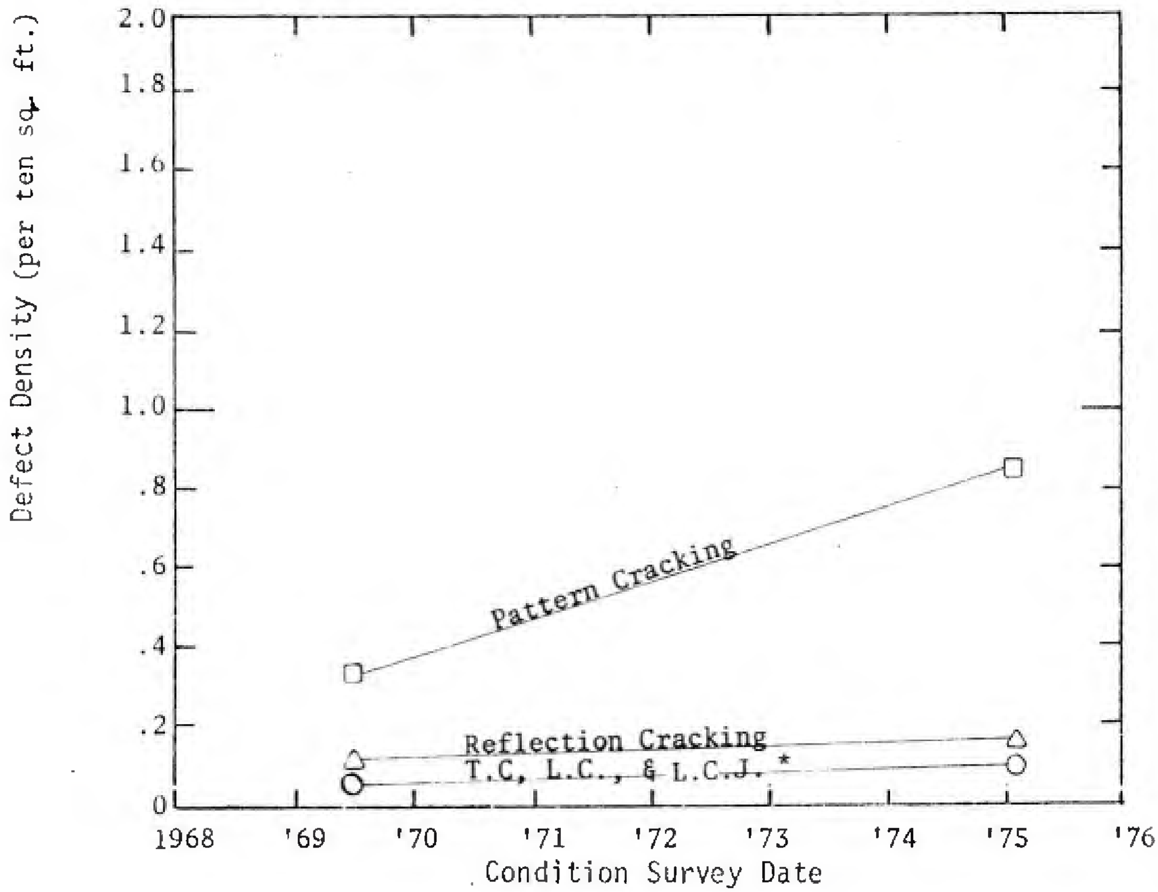
Airfield USMCAS El Toro   Facility Runway 16R-34L

Discrete Area RI6R-2   Pavement Type PCC

Discussion

Joint seal repairs have been accomplished since the last (1969) condition survey. Spalls in this section were not significant, having a density of .01 defect per slab in the 1975 survey, and .02 the 1969 survey.

DISCRETE AREA CONDITION ANALYSIS



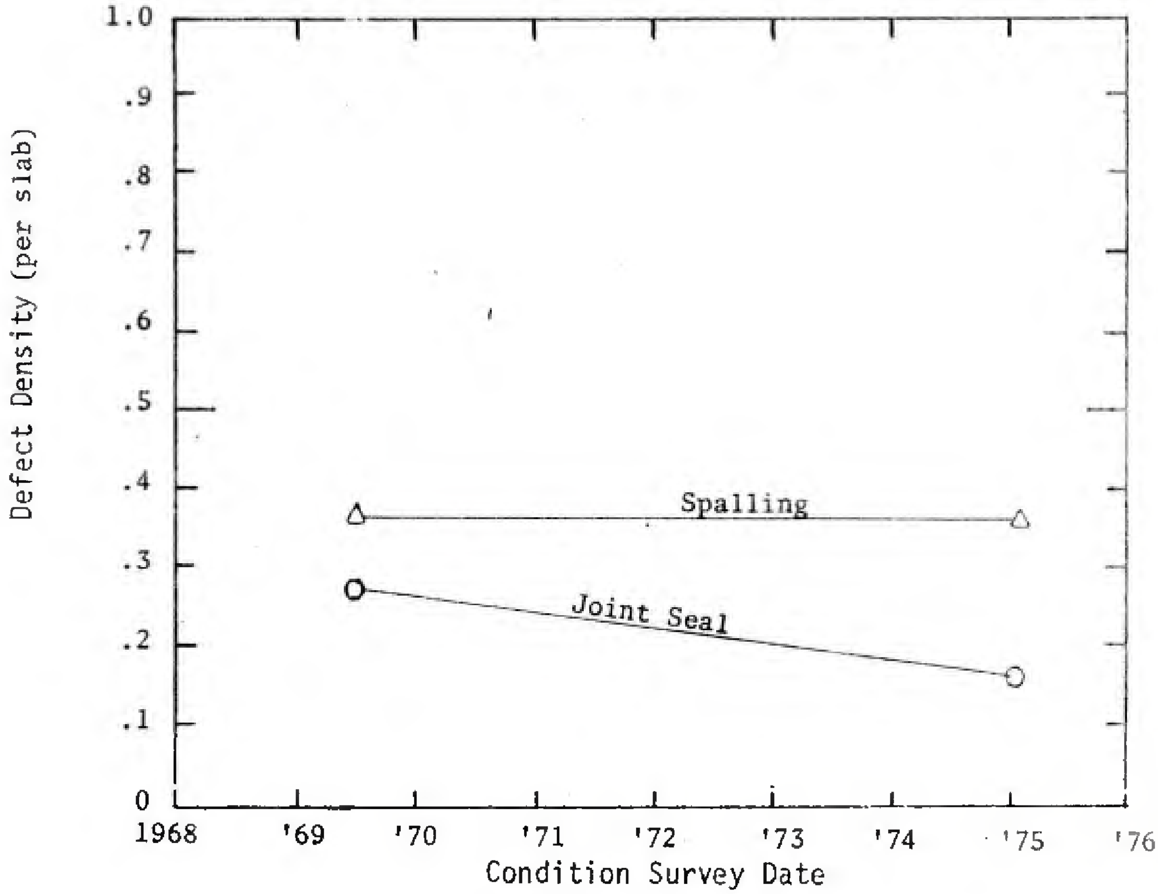
Airfield USMCAS El Toro	Facility Runway 16L-34R
Discrete Area R16L-I	Pavement Type A.C.

Discussion

Pattern cracking density has increased indicating pavement distress increasing with time. Records show station maintenance forces continually cleaning and sealing cracks as they occur.

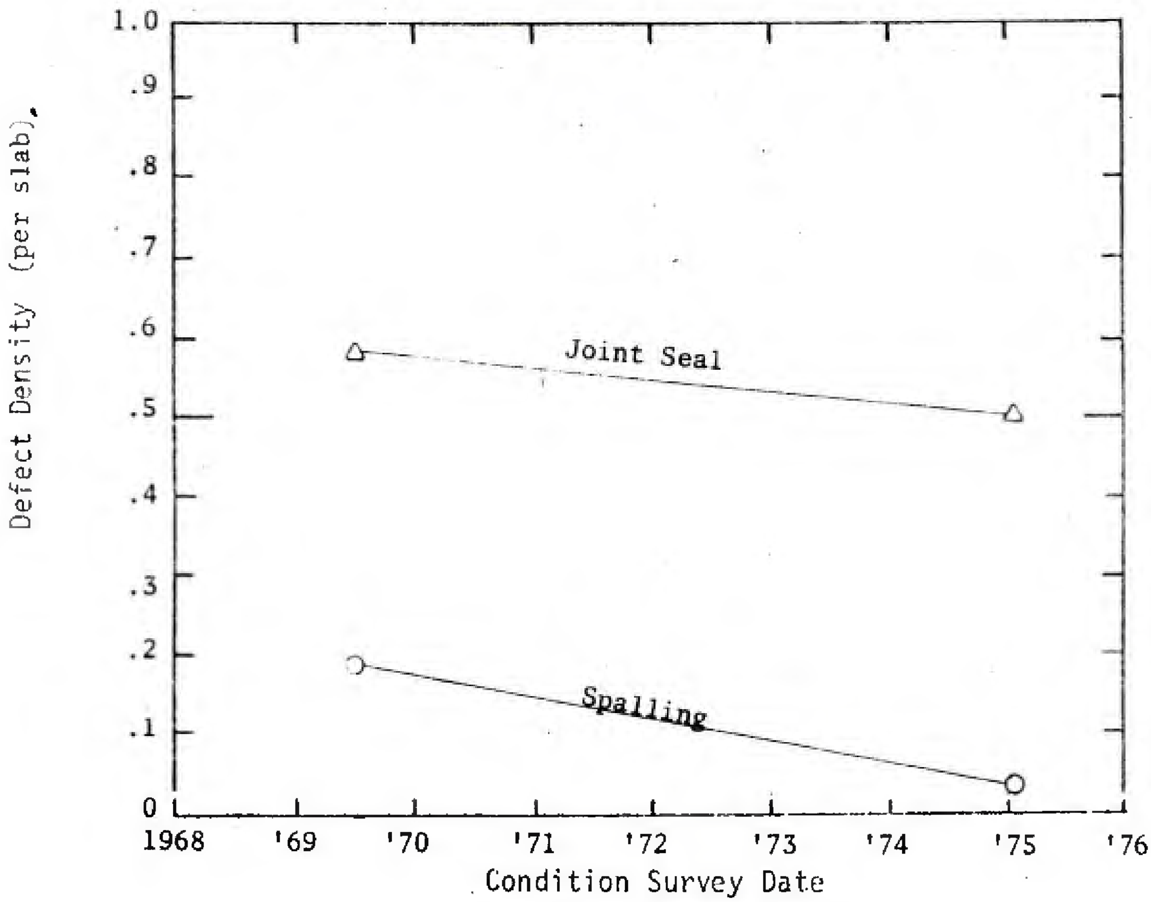
* Transverse crack, longitudinal crack and longitudinal construction joint crack.

DISCRETE AREA CONDITION ANALYSIS



Airfield USMCAS El Toro Facility Runway 16L-34R
Discrete Area R16L-2 Pavement Type PCC
Discussion

Number of spalls was found to be unchanged. Improvement in joint seal defect density probably reflects continuing maintenance effort in joint seal removal and replacement.

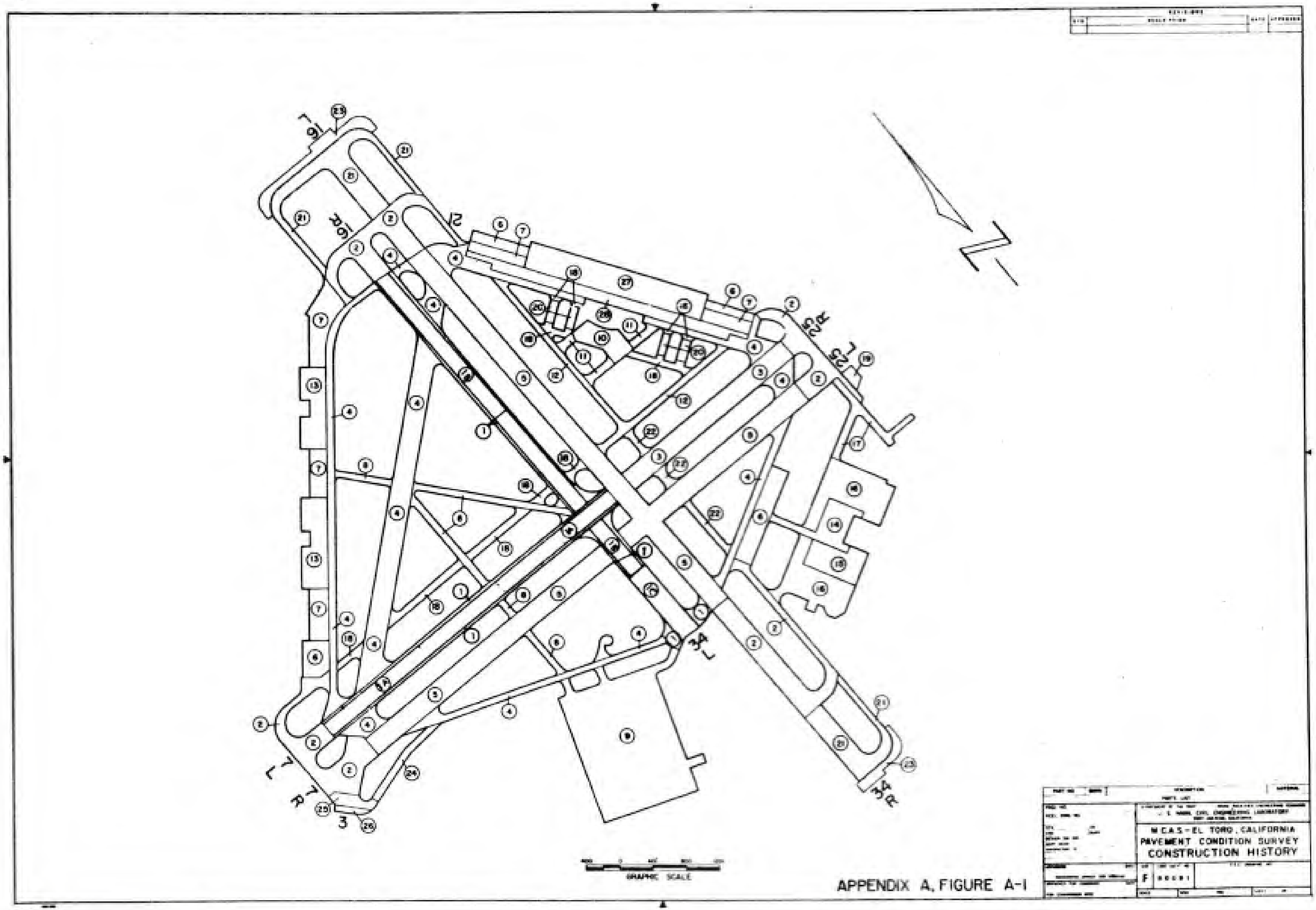


Airfield USMCAS El Toro Facility Runway 16L-34R
Discrete Area R16L-3 Pavement Type PCC
Discussion

Decrease in spalling defect density may reflect spall repair activity by station maintenance forces. Joint seal defects do not appear to have been significantly changed.

APPENDIX A

CONSTRUCTION HISTORY



APPENDIX A, FIGURE A-1

Appendix A

CONSTRUCTION HISTORY FOR USMCAS EL TORO

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
1	<u>Portion of Runways 16R-34L and 7L-25R</u>		
	Slurry seal		1966
	Slurry seal		1961
	Slurry seal		1957
	3" Asphaltic concrete		1951
	5" Crusher run base		1951
	Seal coat		1947
	3" Asphaltic concrete	1942	
	6" Waterbound macadam	1942	
	<u>Shoulders</u>		
	Oil penetration		1951
	12" Subbase		1951
	Oil penetration	1942	
	6" Decomposed granite	1942	
1A	<u>Portion of Runway 7L-25R (Central 180')</u>		
	Reconstruct central 180' by removing 3" of AC and 5" base course placed in 1951 and replace with the following section:		1972
	1½"-2" AC surface course		
	Tack coat		
	4"-5" AC intermediate course		
	Tack coat		
	3" Asphaltic concrete	1942	
	6" Water bound macadam	1942	
1B	<u>Portion of Runway 16R-34L (Central 150')</u>		
	Reconstruct central 150' in the same manner as Item 1A and replace with same AC section.		1974
	3" Asphaltic concrete	1942	
	6" Water bound macadam	1942	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
1C	Portion of Runway 16R-34L (Central 200')		
	Reconstruct central 200' by removing 3" of AC and 5" of base course placed in 1951 and replace with:		1974
	8"-10" portland cement concrete		
	3" Asphaltic concrete	1942	
	6" Waterbound macadam	1942	
2	Portions of Runways 16R-34L, 16L-34R, 7L-25R, 7R-25L, Taxiways, 2, 11, 12 and 19		
	10" Portland cement concrete	1951	
	10" Subbase	1951	
	Shoulders		
	Oil penetration	1951	
	12" Subbase	1951	
3	Portion of Runway 7L-25R		
	Slurry seal		1966
	Slurry seal		1961
	Slurry seal		1957
	4" Asphaltic concrete		1953
	3" Asphaltic concrete		1947
	2½" Asphaltic concrete	1943	
	6" Waterbound macadam	1943	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
4	Portions of Runway 3-21, Taxiways 1, 5 and 9		
	Slurry seal (Taxiways 5 & 9)		1967
	Seal Coat (Runway 3-21)		1966
	Slurry seal		1957
	3" Asphaltic concrete		1951
	5" Base course		1951
	Seal coat		1947
	3" Asphaltic concrete	1942	
	6" Waterbound macadam	1942	
	Shoulders		
	Same as Item 1		
5	Portions of Runways 7R-25L and 16L-34R		
	Slurry seal		1966
	Slurry seal		1961
	Slurry seal		1957
	4" Asphaltic concrete		1951
	Sand emulsion leveling course		1951
	8" Portland cement concrete	1944	
	12" Base course	1944	
	Shoulders		
	Oil penetration		1951
	12" Subbase		1951
	10" Base course	1944	
6	Portions of Parking Apron 3, 4 and 5		
	8" Portland cement concrete	1944	
	12" Base course	1944	
7	Portions of Parking Aprons 4 and 5		
	8" Portland cement concrete	1943	
	14" Base course	1943	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
8	<u>Taxiways 30 and 31</u>		
	Slurry seal		1967
	Slurry seal		1957
	3" Asphaltic concrete		1953
	5" Subbase		1953
	Seal coat		1947
	2½" Asphaltic concrete	1944	
	6" Crusher run base	1944	
	8" Subbase	1944	
9	<u>Parking Apron 1</u>		
	8" Portland cement concrete	1943	
	6" Waterbound macadam	1943	
10	<u>Parking Apron 6</u>		
	10" Portland cement concrete	1955	
	10" Subbase	1955	
11	<u>Taxiway 20</u>		
	Slurry seal		1967
	Slurry seal		1957
	3" Asphaltic concrete	1955	
	9" Base course	1955	
	8" Subbase	1955	
12	<u>Taxiways 17 and 18</u>		
	Slurry seal		1967
	Slurry seal		1957
	3" Asphaltic concrete	1954	
	9" Base course	1954	
	8" Subbase	1954	
13	<u>Portion of Parking Apron 5</u>		
	6" Portland cement concrete	1942	
	6" Waterbound macadam	1942	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
14	<u>Portion of Parking Apron 2</u>		
	10" Portland cement concrete	1952	
	10" Subbase	1952	
15	<u>Portion of Parking Apron 2</u>		
	10" Portland cement concrete	1954	
	10" Subbase	1954	
16	<u>Portion of Parking Apron 2</u>		
	10" Portland cement concrete	1956	
	10" Subbase	1956	
	6" Compacted native material	1956	
	<u>Shoulders</u>		
	Seal coat	1956	
	2" Asphaltic concrete	1956	
	Prime coat	1956	
	10" Base course	1956	
17	<u>Taxiway</u>		
	Seal coat	1956	
	3" Asphaltic concrete	1956	
	Prime coat	1956	
	9" Base course	1956	
	8" Subbase	1956	
	<u>Shoulders</u>		
	Same as Item 16		
18	<u>Taxiway 19</u>		
	Slurry seal		1967
	Slurry seal		1957
	Seal coat	1956	
	3" Asphaltic concrete	1956	
	Prime coat	1956	
	9" Base course	1956	
	8" Subbase	1956	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
18 (Con't)	<u>Shoulders</u>		
	Same as Item 16		
19	<u>Warm-up Apron</u>		
	10" Portland cement concrete	1956	
	10" Subbase	1956	
	6" Compacted native material	1956	
20	<u>Fueling Lanes</u>		
	10" Portland cement concrete	1956	
	10" Subbase	1956	
	6" Compacted native material	1956	
21	<u>Portions of Runway 16L-34R and Taxiways 2 and 12</u>		
	13" Portland cement concrete-reinforced	1959	
	10" Subbase @ 95%	1959	
	12" Subgrade @95%	1959	
	<u>Shoulders (150 feet wide)</u>		
	Seeded	1959	
	6" Compacted native material	1959	
22	<u>Portions of Taxiways 2 and 18</u>		
	11" Portland cement concrete-reinforced	1959	
	10" Subbase @ 95%	1959	
	12" Subgrade @ 95%	1959	
	<u>Shoulders</u>		
	Seeded	1959	
	6" Compacted native material	1959	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
23	Blast Pads and Shoulders		
	Bituminous seal	1959	
	6" Soil cement	1959	
	6" Native material @95%	1959	
24	Taxiway 5 (Extension)		
	Slurry seal		1967
	4" Asphaltic concrete	1962	
	8" Base course - 80 CBR	1962	
	10" Base course - 40 CBR	1962	
25	Portions of Ruwnay 3-21 and Taxiway 5 (Extension)		
	11" Portland cement concrete	1962	
	6" Base course - 40 CBR	1962	
26	Blast Pad and Shoulder		
	6" Portland cement concrete	1962	
27	Portion of Parking Apron 4		
	10" Portland cement concrete	1968-69	
	6" Subbase (40 CBR) @ 100%	1968-69	
	6" Native material @ 95%	1968-69	
	18" Native material @ 95%	1968-69	
28	Taxiway 14		
	11" Portland cement concrete	1964	
	6" Subbase (40 CBR) @ 100%	1964	
	24" Native material @ 95%	1964	

APPENDIX B

CLIMATOLOGICAL DATA

APPENDIX B

CLIMATOLOGICAL DATA FOR USMCAS EL TORO, CALIFORNIA

Month	Temperature Means (°F) Daily Max.	Daily Min.	Temperature Extremes (°F) Record High	Record Low	Precipitation (in.) Mean Monthly	Record Maximum Monthly	Record Minimum Monthly
January	63.6	44.0	93	25	2.75	8.89	0.23
February	65.5	45.2	88	30	1.91	6.66	T
March	66.6	46.0	88	32	1.80	7.76	T
April	69.2	49.0	101	33	1.46	5.40	T
May	71.9	52.4	101	39	0.24	.084	T
June	75.6	56.0	103	45	0.05	0.25	T
July	81.7	60.1	103	50	0.03	0.34	0.00
August	82.6	61.0	102	47	0.03	0.35	T
September	81.4	59.2	116	45	0.23	2.19	0.00
October	77.3	55.1	108	38	0.23	1.48	T
November	70.9	50.1	97	35	1.68	6.70	0.00
December	65.9	46.0	93	30	1.73	5.28	T

Note: Weather data covers an 18 year period.

*T = Trace, an amount too small to measure

Data Source: Naval Weather Service. Local Climatological Data for Selected U.S. Navy and Marine Corps Air Stations, Asheville, North Carolina, June 1968.

APPENDIX C

CONDITION SURVEY PROCEDURES

Appendix C

CONDITION SURVEY PROCEDURES

Step 1. Preliminary Survey

In the preliminary survey the evaluators make a general and personal inspection of all airfield pavement areas, during which they note the type and distribution of defects in each facility (runway, taxiway, etc.). In addition, a previously-prepared construction history is consulted and areas of different construction and different pavement type (AC or PCC) within a facility are noted. As a result of these efforts, each pavement facility is then divided into "discrete areas" of reasonably similar failure modes for performance of the subsequent sampling and tally or measurement of defects. Thus, if the type and/or number of defects found in one portion of a facility are distinctly different from those found in another portion of that facility, discrete areas are selected on this basis. If, however, the pavement facility contains few defects or if the defects found are similar in type and distribution throughout the facility, each facility is individually divided for survey according to the construction history. Under either criterion, a discrete area may vary, for example, from a 500-foot length of runway or taxiway to the entire length of the facility. All discrete areas are numbered with a system that relates the discrete area to the runway, taxiway, etc., of which it is a part. For example, discrete areas comprising Runway 11-29 are designated R 11-1 and R 11-2, etc;, discrete areas for Taxiway 2 are T 2-1 and T 2-2, etc.

A special survey of singular occurrences of serious defects is made during the preliminary survey. This is necessary because the statistical sampling techniques utilized in the subsequent survey are effective in spotting defects only when such defects are numerous and/or relatively well distributed. This abbreviated special survey provides information on those infrequent defects, if any, which may present a problem to safe aircraft operation.

Step 2. Statistical Sampling and Defect Survey

After discrete areas are selected, a number of small "sample areas" are chosen within each discrete area. The total number of sample areas is determined by statistical theory as a function of the relative size of the discrete area. Actual locations of the sample areas are selected at random from the discrete area.

Sample areas in PCC pavements basically consist of individual slabs, usually 12½ x 15 feet in size. For the convenience of the evaluators, either a single slab or a number of adjacent slabs can be considered as a sample area Both types of sampling area are shown schematically in Figure C-1. Note from Figure C-1 that individual sample slabs and/or sample strips are selected within the center 100 feet (laterally) of runways and within the center 50 feet (laterally) of taxiways by a random selection process. For parking aprons, mats, etc., similar sample areas are selected at random over the entire pavement area.

For AC pavements, sample areas are fifty-foot-square areas located as shown in Figure C-2. For parking aprons, mats, etc. (not shown in Figure C-2) sample areas are fifty-feet square, as for other traffic areas, and randomly located over the entire pavement area.

All defects or defected slabs in each of the selected sample areas are noted on appropriate data sheets. For PCC pavement slabs or sample strips, either single or multiple occurences of a given defect type within the slab qualify the slab as a defected slab. For example, one or more spalls qualifies a slab as a spalled slab. A crack in the same slab requires that it be counted again, this time as a cracked slab. No measurement of length, area, etc. is recorded for PCC pavement defects. When a sample slab strip is chosen for test, the above mentioned tally method (slab by slab) is still utilized.

The defects found in AC sample areas are measured and tallied, rather than merely tallied as are those for PCC pavements. Depending on the type of defect, the total length in feet (for cracks, etc.) or total area in square feet (for pattern cracking, raveling, etc.) is recorded.

The above survey of defects found in sample areas (in each discrete area) are shown in column (c) of the Discrete Area Defect Summary sheets, Figures C-3 and C-4. Separate summary sheets are provided for portland cement concrete (PCC) and asphaltic concrete (AC) pavements. Total extrapolation of the defect data in column (c), and are shown in column (d) of the Discrete Area Defect Summary sheets. To remove the influence of the size of the discrete area on the total defect count (i.e., the count is divided by either the number of slabs in the discrete area (for PCC pavements) or by the area (in 10-sqaure-foot increments) of the discrete area (for AC pavements). This gives a defect <u>density</u> (per slab or per 10 square feet) which is listed in column (e).

Step 3. Defect Severity Weighting System

A weighting system, providing a numerical weight for each type defect in proportion to the relative severity of that defect, is applied in the following manner to each of the defect counts in the discrete area;

given defect density x weight for that type defect = weighted defect density

This is accomplished in columns (f) and (g) of the Discrete Area Defect Summary sheets. Next, a total weighted defect density is obtained for each discrete area by summing column (g) of these sheets. Note that a letter suffix is added to each total weighted defect density for the purpose of further distinguishing between asphaltic concrete defect densities (suffix "A") and portland cement concrete defect densities (suffix "C").

The defect weighting guide developed by NCEL assigns greater weights to defects that (1) presently affect the safe operation of aircraft or the cost of aircraft operation; (2) will lead to increased airfield pavement maintenance costs; or (3) will result in significant deterioration of load-carrying capacity of the pavements. The resultant numerical weights are further modified to reflect variations in pavement environment from station to station. For example, higher (more severe) weights are assigned to defects which are affected by factors such as freezing weather, heavy rainfall, or blow sand for surveys of airfields located in areas where these undesirable environmental effects occur. Thus, it can be seen that the higher the numerical weighted defect density, the poorer the condition of the surveyed pavement.

Remarks concerning the general pavement condition and the defects identified are given in narrative form on each Discrete Area Summary sheet. In addition, photographs of typical pavement conditions noted during the survey are used to further illustrate typical pavement defects.

Step 4. Facility Summary--Weighted Defect Densities

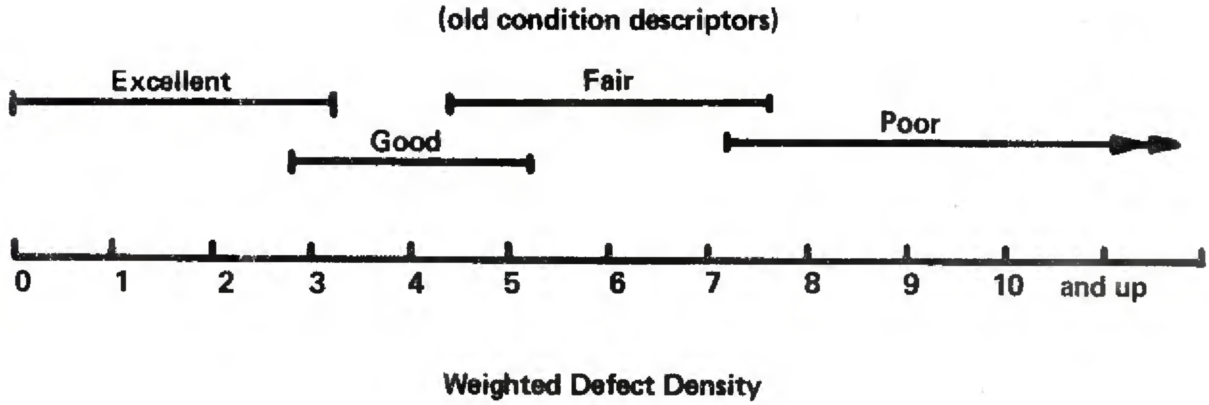
A final step in providing a numerical condition rating for each facility (runway, taxiway, etc.) is accomplished in the Facility Defect Summary sheets, Figures C-5 and C-6. Again note that separate sheets have been provided for AC and PCC pavements. In these sheets the individual weighted defect densities for all discrete areas comprising the entire AC or PCC portion of a facility (runway, taxiway, etc.) are summarized in column (a). When an AC or PCC facility (or portion) has been divided into more than one discrete area for the condition survey, the proportional contribution of each discrete area to the entire AC or PCC facility area is determined in column (b). In column (c) these proportions are applied to the individual discrete area weighted defect densities listed in column (a) and added to obtain an overall average weighted defect density for the entire AC or PCC portion of the facility (marked "total" in column (c). When an entire AC or PCC facility (or portion) has been designated a single discrete area (as often occurs), the proportionality factor in column (b) is obviously 1.00 and the discrete area weighted defect density from column (a) becomes the average weighted defect density for the entire facility (or portion) in column (c).

GENERAL COMMENTS ON CONDITION SURVEY PROGRAM

The weighted defect densities, listed in column (a) of the Facility Defect Summary for individual discrete pavement areas and in column (c) as averaged weighted defect densities for entire AC or PCC runways, taxiways, etc. (or portions thereof) represent, numerically, the surface condition of the airfield pavements at the station. As previously stated, the larger defect density numbers indicated basically a greater number and/or severity of defects per unit area of pavement, i.e., a poorer pavement. Thus, they represent the final product of the pavement condition survey. It should be noted specifically, however, that AC and PCC pavement defect densities, although often numerically similar, are obtained by two different condition survey techniques and, as such, are <u>not numerically compatible</u> and <u>must not be combined</u>. (It is largely because of this fact that the letter suffixes "A" and "C" have been affixed to defect densities for AC and PCC pavements respectively.) As an example, consider the common case of an AC runway with PCC ends. The condition survey system presented herein provides indivdual discrete are weighted defect densities for discrete areas selected on <u>both</u> AC and PCC pavements, but provides a <u>separate</u> average weighted defect density for the enitre AC portion and a <u>separate</u> average weighted defect density for the combined PCC end pavements. It is not possible to combine these defect densities to obtain an average AC/PCC defect density for the entire runway. Thus the defect densities for AC and PCC are reported separately, given different letter suffixes, and should include the letter suffix when reference is made to them.

Individual numerical defect densities, however accurately they indicate pavement condition, may mean little to the reader of an individual airfield condition survey report, for he has no basis upon which to judge the relative severity of pavement condition associated with the numbers obtained for his pavements. The primary value of a numerical condition survey program will be the accumulation of uniformly-obtained, comparative condition data for <u>many</u> airfields which can best be correlated, studied, and used in the decision-making processes at headquarters levels.

For the benefit of the individual reader, however, an effort was made during the first year of pavement condition surveys (FY-70) to relate the numerical condition (defect densiteis) to the basic subjective condition descriptors (excellent, good, fair, poor, etc.) used in all previous Navy pavement evaluation procedures. Although the subjective condition-descriptor approach is poorly regarded as a means of comparing pavement condition from one airfield to another, the following diagram may serve temporarily as a rudimentary bridge between the old subjective system and the new (numerical) condition approach:



The system of numerical defect densities was developed to aid in determining the suitability of airfield pavement surfaces for satisfying aircraft operational requirements and to establish an unbiased, uniform basis for initiating maintenance and repair efforts. As such, defect densities are simply visually-determined indicators of the condition of the pavement and do not represent true "condition ratings" in that they do not include factors relating to pavement strength, traffic usage, etc. It is possible that additional measurements or modifications may be considered necessary or desirable in future condition survey programs.

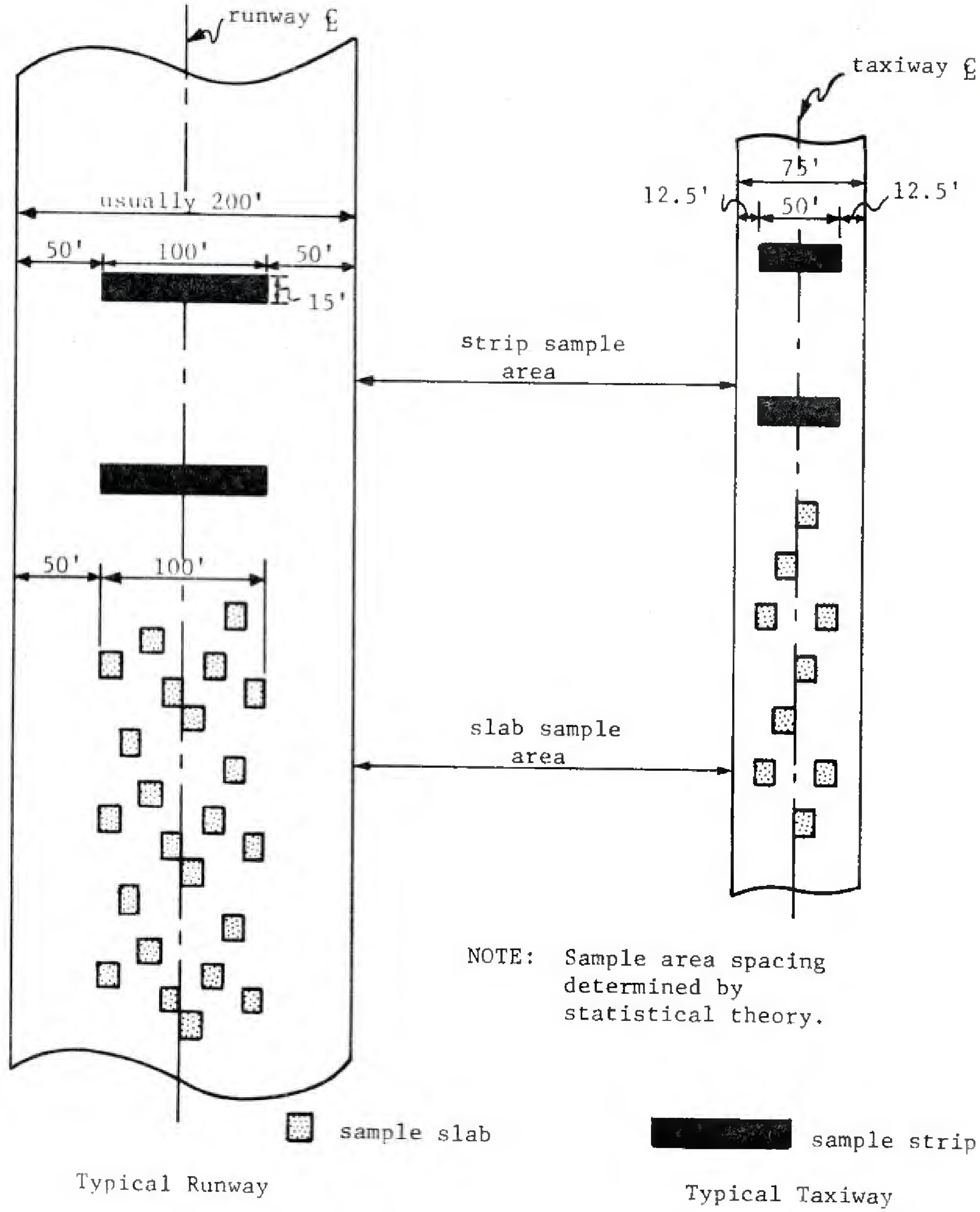


Figure C-1. Portland cement concrete sample areas.

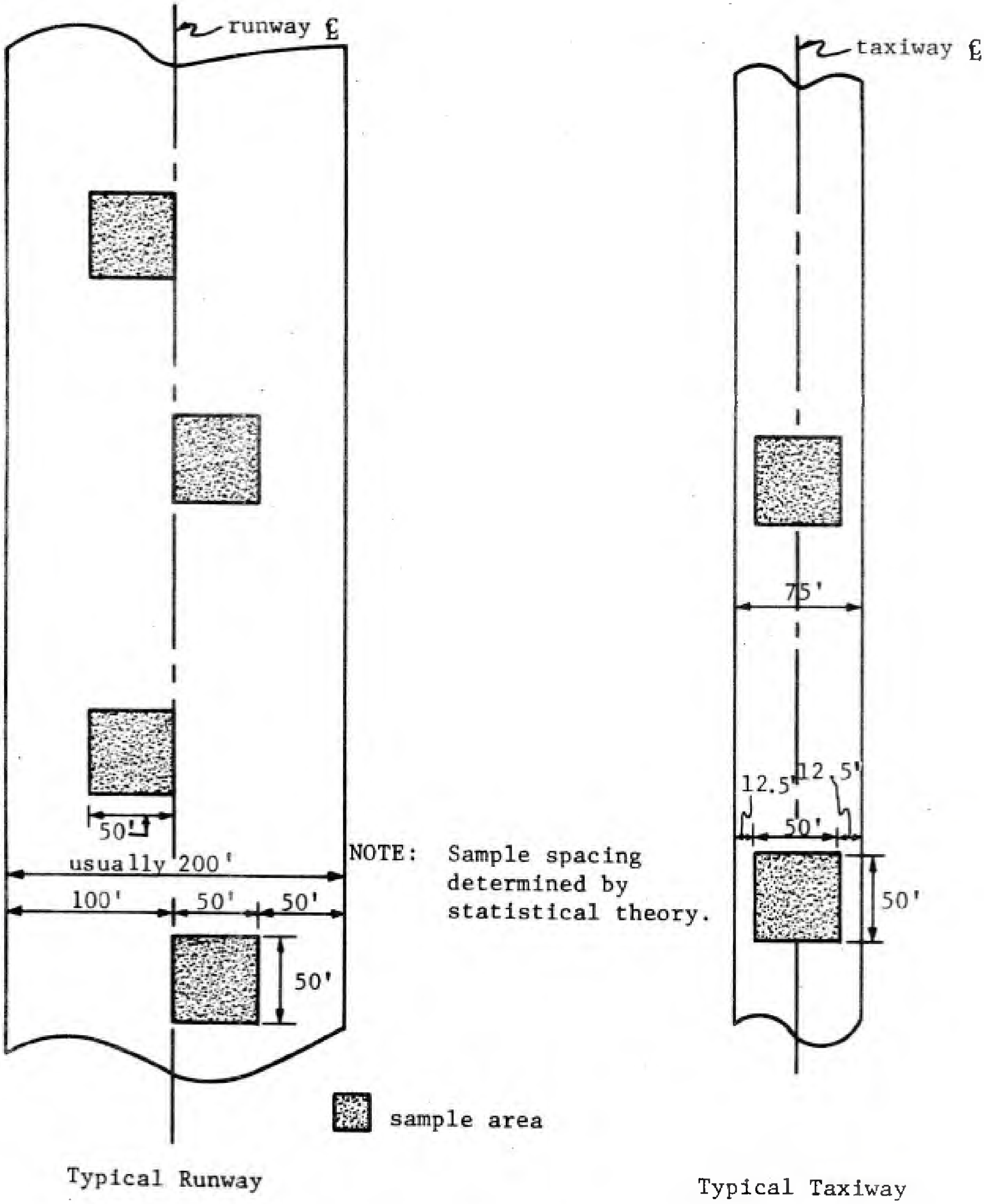


Figure C-2. Asphaltic concrete sample areas.

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield E X A M P L E Facility Taxiway 2

Discrete Area T2-1 Area of Discrete Area (a) 97,700 ft^2

No. of Sample Areas (b) 10 Ratio: (a/2500b) 3.9

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects: (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density: (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ*	80 ft	312 ft	0.0319	2.5	0.0798
Reflection Crack					
Faulting					
Patching					
Settlement or Depression	530 ft^2	2,067 ft^2	0.2116	9.0	1.9041
Pattern Cracking	126 ft^2	491.4 ft^2	0.0503	2.5	0.1257
Rutting					
Heaving					
Erosion—Jet Blast					
Oil Spillage					
Broken-up Area					
				Total	2.11 A**

Remarks on Pavement Condition

The depressions were generally 1/2" deep. Pattern cracking formed 6" to 12" polygons and was associated with the depressions. Longitudinal cracks were unsealed and 1/8" wide. (See Figure 5.)

* Transverse crack, longitudinal crack, and longitudinal construction joint

** Letter suffix "A" indicates asphaltic concrete pavement

Figure C-3. Typical Asphaltic Concrete Discrete Area Defect Summary

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield EXAMPLE Facility Taxiway 2

Discrete Area T2-2 Total Slabs in Discrete Area (a) 1,542

No. of Slabs Sampled (b) 193 Ratio a/b = 8.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break	1	8	0.0052	2.5	0.013
L.C. or T.C. *	19	152	0.0985	1.0	0.098
I.C. **	1	8	0.0052	2.5	0.013
Depression		2***	0.0013	9.0	0.012
Spalling	59	472	0.3060	7.5	2.295
Scaling					
Disintegrated Slab					
Joint Seal	10	80	0.0518	2.5	0.130
Pumping					
				Total	2.57 C****

Remarks on Pavement Condition

Spalls were generally 1" wide by 3" long with some spalls up to 4" wide and 12" long. The longitudinal cracks found were mostly sealed. The depressions noted as singular defects consisted of two depressed and cracked slabs. The depression was approximately 1/2" deep. An attempt had been made to repair these slabs with portland cement concrete. Joint seal was missing in strips 4" to 12" long. (See Figures 25 and 26.)

* Longitudinal crack or transverse crack
** Intersecting crack
*** Counted as singular defects during the preliminary survey
**** Letter suffix "C" indicates portland cement concrete pavement

Figure C-4. Typical Portland Cement Concrete Discrete Area Defect Summary

ASPHALTIC CONCRETE FACILITY DEFECT SUMMARY

Airfield E X A M P L E

Date Surveyed ______

Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Taxiway 2			
T2-1	2.11 A	1.00	2.11 A
Taxiway 10			
T10-2	0.004 A	1.00	0.004 A
Towway 1			
TOW-1	3.77 A	1.00	3.77 A
Parking Apron 2			
PA2-1	7.29 A	1.00	7.29 A
Parking Apron 6			
PA6-1	7.44 A	1.00	7.44 A
Parking Apron 7			
PA7-1	4.97 A	0.79	3.93
PA7-2	23.18 A	0.21	4.87
			8.80 A (Total)
Parking Apron 8			
PA8-1	2.76 A	1.00	2.76 A
Central Mat			
CM-1	2.89 A	1.00	2.89 A

* If facility entirely constructed of AC, indicates total facility area. If facility only partly constructed of AC, indicates total area of AC portion of facility.

** Letter suffix "A" on weighted defect densities indicates asphaltic concrete pavements.

Figure C-5. Typical Asphaltic Concrete Facility Defect Summary

PORTLAND CEMENT CONCRETE FACILITY DEFECT SUMMARY

Airfield E X A M P L E

Date Surveyed

Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Runway 11-29			
R11-1	0.80 C	0.25	0.02
R11-2	4.43 C	0.75	3.33
			3.35 C (Total)
Runway 18-36			
R18-1	1.25 C	0.68	0.85
R18-2	0.76 C	0.32	0.28
			1.13 C (Total)
Taxiway 1			
T1-1	2.82 C	0.12	0.34
T1-2	0.98 C	0.88	0.86
			1.20 C (Total)
Taxiway 2			
T2-2	2.57 C	1.00	2.57 C
Taxiway 3			
T3-1	1.82 C	1.00	1.82 C
Taxiway 4			
T4-1	3.02 C	1.00	3.02 C
Taxiway 5			
T5-1	0.98 C	1.00	0.98 C
Taxiway 6 and Taxiway 7			
T6-1 and T7-1	0.06 C	1.00	0.06 C

* If facility entirely constructed of PCC, indicates total facility area. If facility only partly constructed of PCC, indicates total area of PCC portion of facility.

** Letter suffix "C" on weighted defect densities indicates Portland cement concrete pavements.

Figure C-6. Typical Portland Cement Concrete Facility Defect Summary

APPENDIX D

MU-METER COEFFICIENT OF
FRICTION AFTER WETTING

APPENDIX D
MU-METER COEFFICIENTS OF FRICTION
AFTER WETTING. USMCAS EL TORO, CALIFORNIA

Test Location and Run No.	Runway Heading	Average Time After Wetting Min	Average Coefficient Of Friction (Mu)	Maximum Coefficient Of Friction (Mu)	Minimum Coefficient Of Friction (Mu)
Runway 7L-25R					
Test Section A					
1	7	2.26	.29	.77	.03
2	25	3.73	.47	.81	.18
3	7	5.55	.46	.83	.16
4	25	7.24	.48	.82	.25
5	7	9.19	.52	.82	.22
6	25	12.95	.56	.82	.22
7	7	17.65	.67	.82	.42
8	25	27.79	.60	.82	.34
Test Section B					
1	7	1.52	.74	.80	.56
2	25	3.77	.79	.82	.69
3	7	5.08	.79	.82	.69
4	25	7.98	.82	.83	.73
5	7	14.34	.82	.83	.80
6	25	22.19	.79	.81	.78
Test Section C					
1	7	2.23	.32	.44	.12
2	25	3.00	.31	.55	.04
3	7	4.56	.37	.56	.22
4	25	5.90	.42	.67	.13
5	7	7.27	.44	.61	.24
6	25	10.65	.55	.71	.37
7	7	14.17	.64	.74	.38
8	25	20.17	.66	.84	.26
9	7	26.96	.78	.84	.64

Test Location and Run No.	Runway Heading	Average Time After Wetting Min.	Average Coefficient of Friction (Mu)	Maximum Coefficient of Friction (Mu)	Minimum Coefficient of Friction (Mu)
Runway 7R-25L					
Test Section A					
1	7	2.27	.53	.67	.34
2	25	2.94	.48	.77	.22
3	7	4.50	.67	.81	.32
4	25	5.99	.67	.85	.30
5	7	7.33	.69	.85	.35
6	25	8.57	.77	.87	.50
7	7	13.41	.83	.85	.62
8	25	19.65	.84	.86	.62
Test Section B					
1	7	2.12	.68	.78	.36
2	25	2.99	.71	.78	.40
3	7	4.41	.72	.80	.44
4	25	5.80	.76	.80	.44
5	7	7.42	.76	.83	.50
6	25	12.97	.80	.84	.67
7	7	20.78	.79	.80	.69
Test Section C					
1	7	2.20	.61	.79	.23
2	25	2.98	.69	.79	.42
3	7	4.42	.76	.83	.58
4	25	5.69	.76	.83	.56
5	7	7.43	.83	.85	.74
6	25	13.25	.82	.85	.71
7	7	21.18	.84	.85	.70
8	25	25.21		.87	.80
Test Section D					
1	7	2.16	.44	.60	.18
2	25	2.87	.53	.65	.29
3	7	4.20	.61	.75	.32
4	25	5.52	.64	.78	.42
5	7	7.15	.71	.80	.48
6	25	8.86	.72	.84	.44
7	7	11.86	.73	.84	.38
8	25	15.94	.80	.86	.63
9	7	23.67	.80	.85	.67

Test Location and Run No.	Runway Heading	Average Time After Wetting Min.	Average Coefficient of Friction (Mu)	Maximum Coefficient of Friction (Mu)	Minimum Coefficient of Friction (Mu)
Runway 16L-34R					
Test Section A					
1	34	2.15	.35	.51	.13
2	16	2.95	.35	.46	.15
3	34	4.27	.43	.60	.11
4	16	5.05	.40	.65	.16
5	34	7.74	.51	.75	.18
6	16	10.14	.50	.70	.18
7	34	15.99	.60	.79	.19
8	16	19.65	.61	.80	.21
9	34	28.19	.71	.80	.29
Test Section B					
1-AC	34	2.23	.35	.39	.26
PCC			.39	.56	.23
2-AC	16	2.96	.42	.53	.37
PCC			.32	.50	.04
3-AC	34	4.34	.39	.50	.29
PCC			.38	.70	.06
4-AC	16	5.92	.46	.56	.38
PCC			.46	.64	.28
5-AC	34	8.58	.42	.53	.27
PCC			.48	.66	.10
6-AC	16	14.63	.57	.68	.47
PCC			.58	.72	.34
7-AC	34	21.00	.59	.68	.48
PCC			.63	.76	.24
8-AC	16	27.79	.70	.73	.61
PCC			.71	.79	.34
Test Section C					
1	34	2.22	.46	.70	.21
2	16	3.00	.49	.73	.22
3	34	4.22	.59	.79	.24
4	16	5.44	.59	.78	.34
5	34	9.32	.78	.85	.42
6	16	12.74	.76	.83	.51
7	34	18.47	.83	.87	.68
8	16	23.43	.84	.85	.70
Test Section D					
1	34	2.78	.78	.85	.48
2	16	3.52	.71	.84	.36
3	34	4.84	.81	.85	.51
4	16	6.67	.78	.83	.60
5	34	9.07	.83	.86	.61
6	16	17.08	.82	.85	.68
7	34	23.52	.83	.88	.63

Test Location and Run No.	Runway Heading	Average Time After Wetting Min.	Average Coefficient of Friction (Mu)	Maximum Coefficient of Friction (Mu)	Minimum Coefficient of Friction (Mu)
Runway 16R-34L					
Test Section A					
1	34	2.23	.68	.74	.50
2	34	2.62	.74	.80	.44
3	34	5.90	.76	.82	.58
4	34	8.00	.79	.86	.58
5	16	10.20	.78	.88	.50
6	34	14.47	.83	.88	.65
7	16	17.86	.81	.86	.64
8	34	25.41	.82	.85	.61
Test Section B					
1	34	2.20	.48	.54	.37
2	16	3.42	.59	.64	.48
3	34	4.87	.63	.68	.49
4	16	8.45	.63	.70	.44
5	34	9.99	.66	.72	.59
6	16	13.77	.72	.75	.68
7	34	20.64	.81	.83	.73
8	16	26.56	.81	.82	.78
Test Section C					
1-AC	16	2.26	.55	.65	.38
PCC			.69	.79	.64
2-AC	34	2.99	.58	.68	.48
PCC			.74	.77	.48
3-AC	16	4.46	.55	.67	.40
PCC			.67	.85	.57
4-AC	34	6.93	.68	.75	.56
PCC			.77	.79	.66
5-AC	16	9.45	.68	.74	.53
PCC			.70	.75	.51
6-AC	34	15.65	.77	.82	.64
PCC			.76	.78	.64
7-AC	16	20.41	.78	.82	.70
PCC			.70	.74	.58
8-AC	34	24.36	.82	.84	.77
PCC			.80	.82	.78

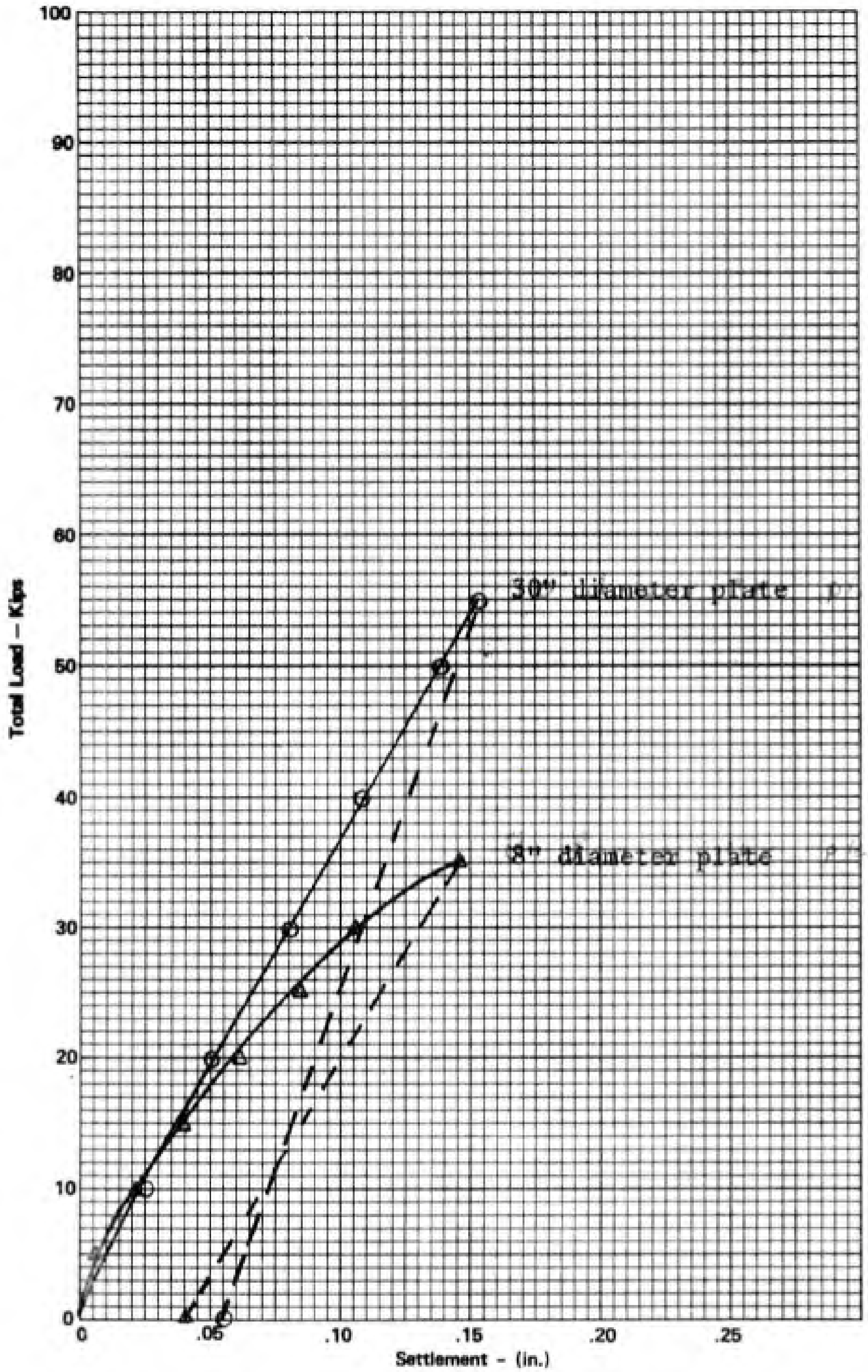
APPENDIX E

TOTAL LOAD VS. DEFLECTION
SURFACE PLATE LOAD TESTS

11ND-NCEL-3960/20 (REV. 6-68)

TOTAL LOAD VS. DEFLECTION

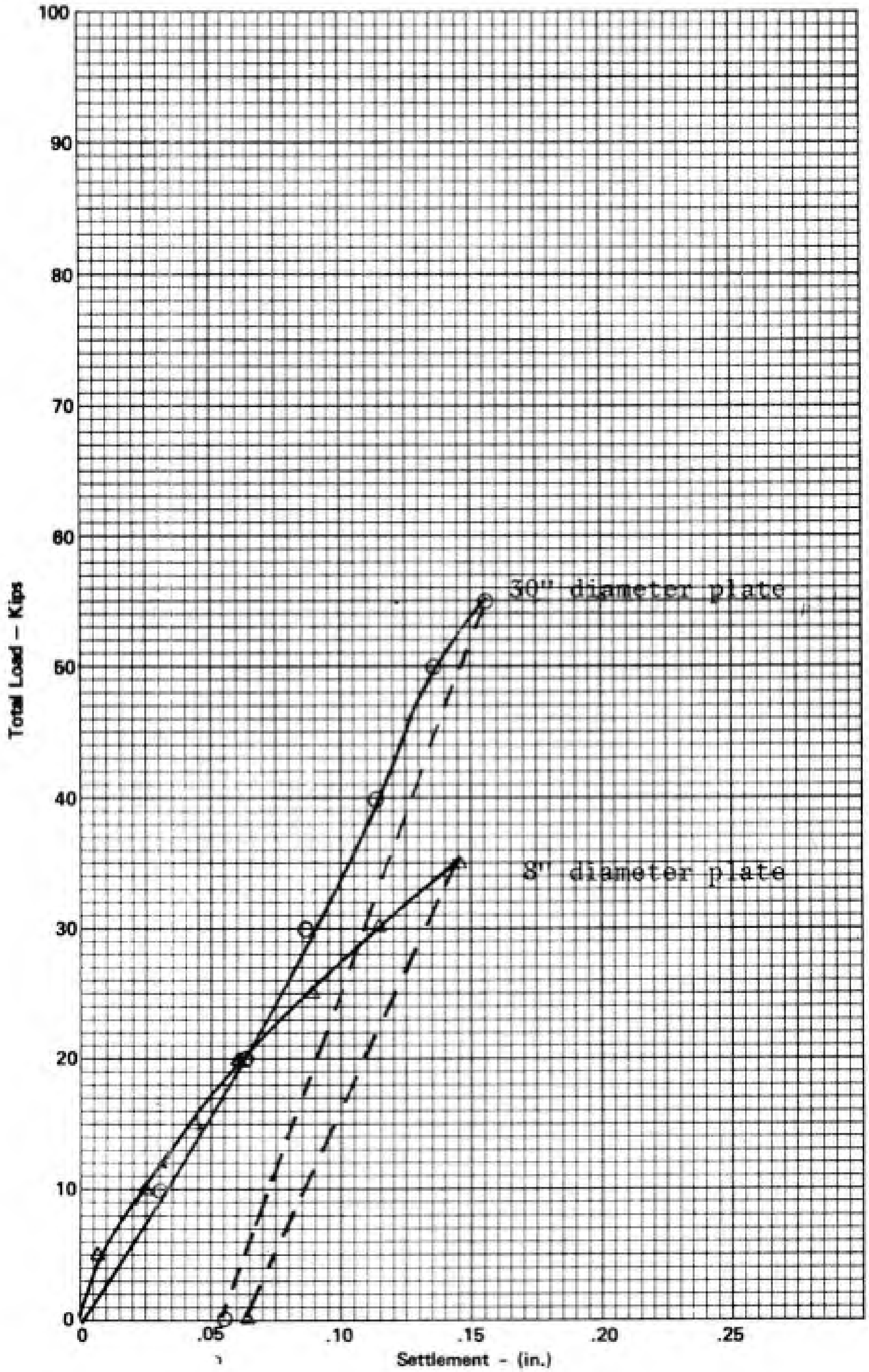
FACILITY	LOCATION	STATION
MCAS El Toro	Runway 16R-34L	25+00 25'R



11ND-NCEL-3960/20 (REV. 6-68)

TOTAL LOAD VS. DEFLECTION

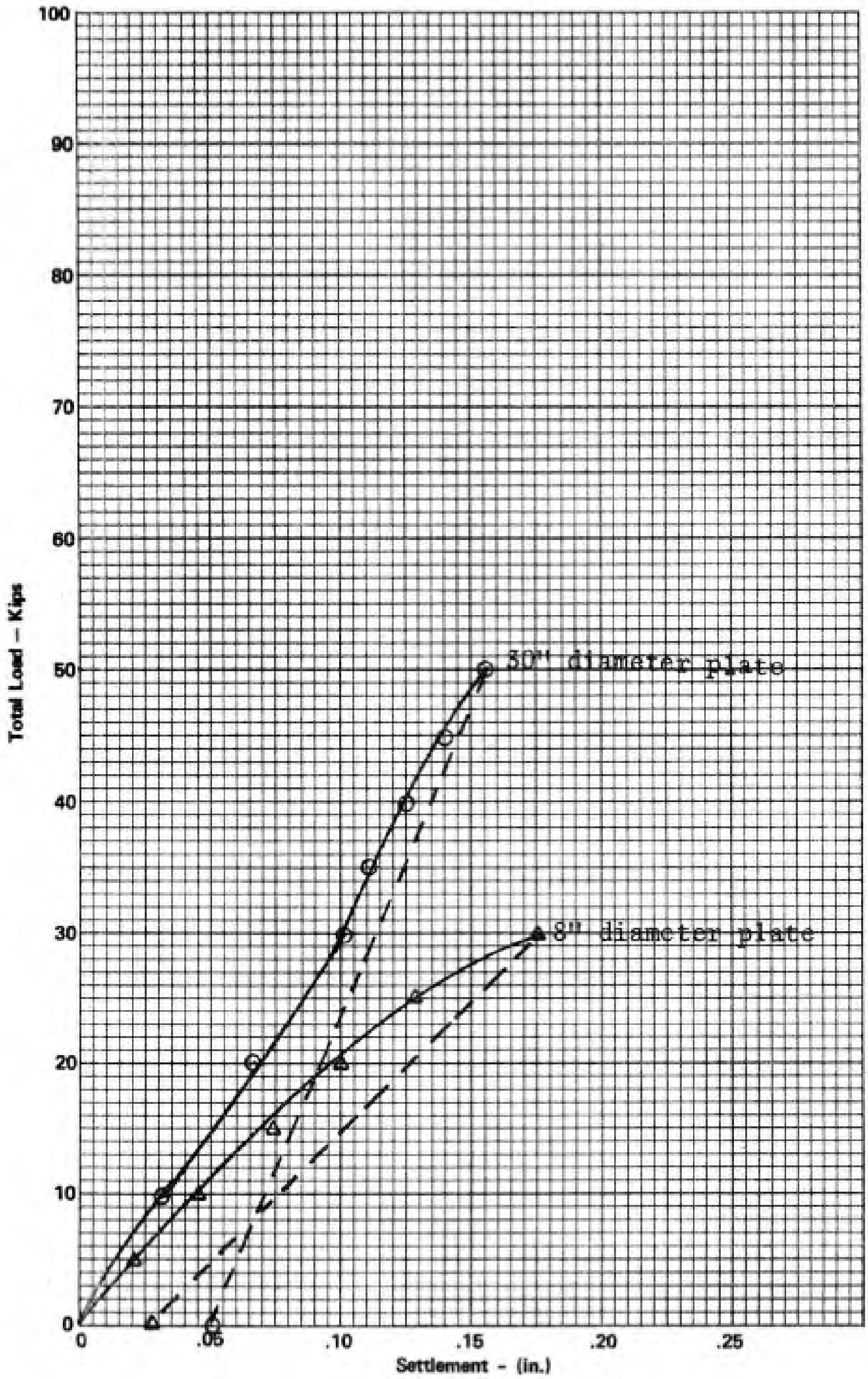
FACILITY	LOCATION	STATION
MCAS El Toro	Runway 16R-34L	25+00 25'L



11ND–NCEL–3960/20 (REV. 6-68)

TOTAL LOAD VS. DEFLECTION

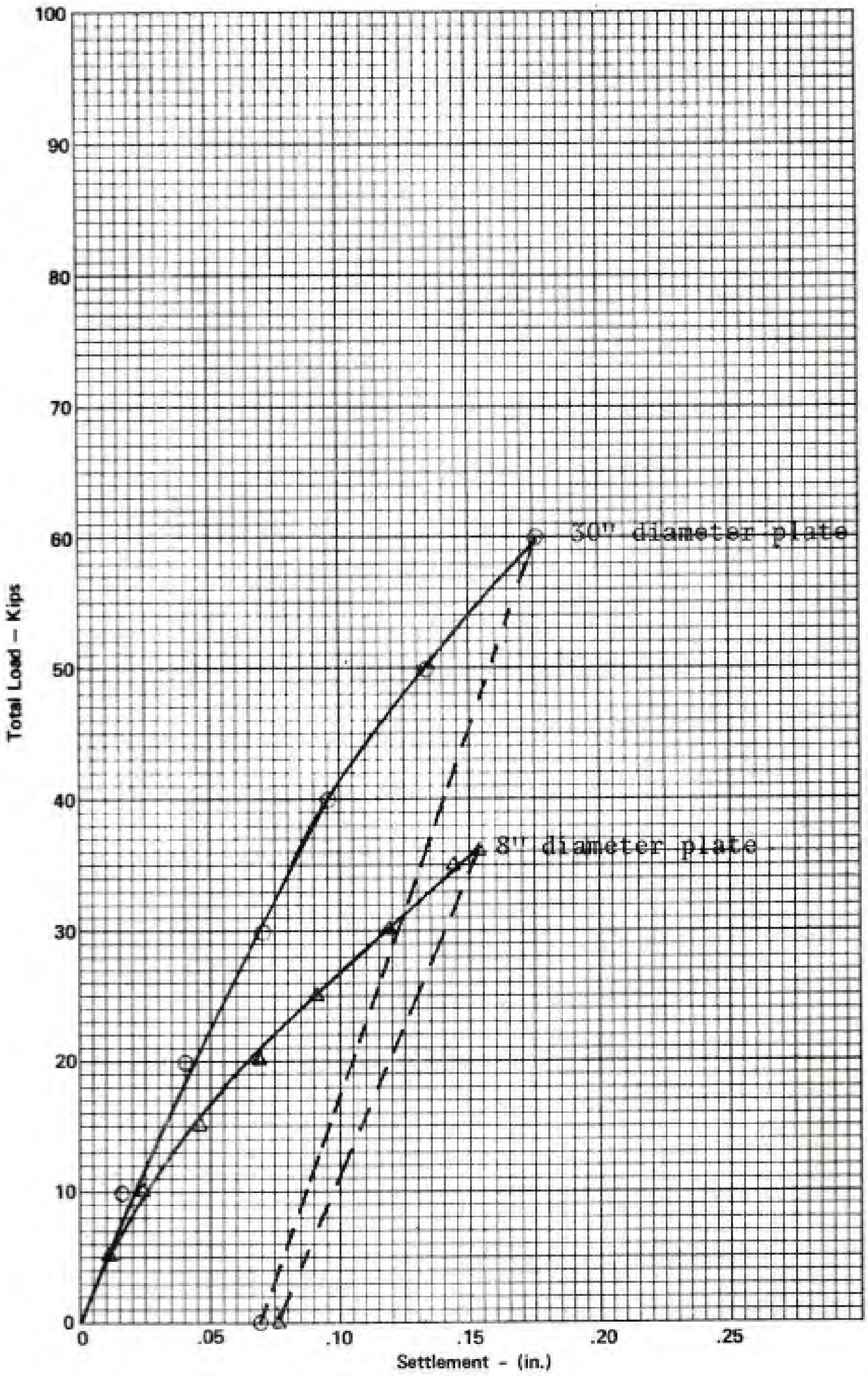
FACILITY	LOCATION	STATION
MCAS El Toro	Runway 16R-34L	25+00 ℄



11ND-NCEL-3960/20 (REV. 6-68)

TOTAL LOAD VS. DEFLECTION

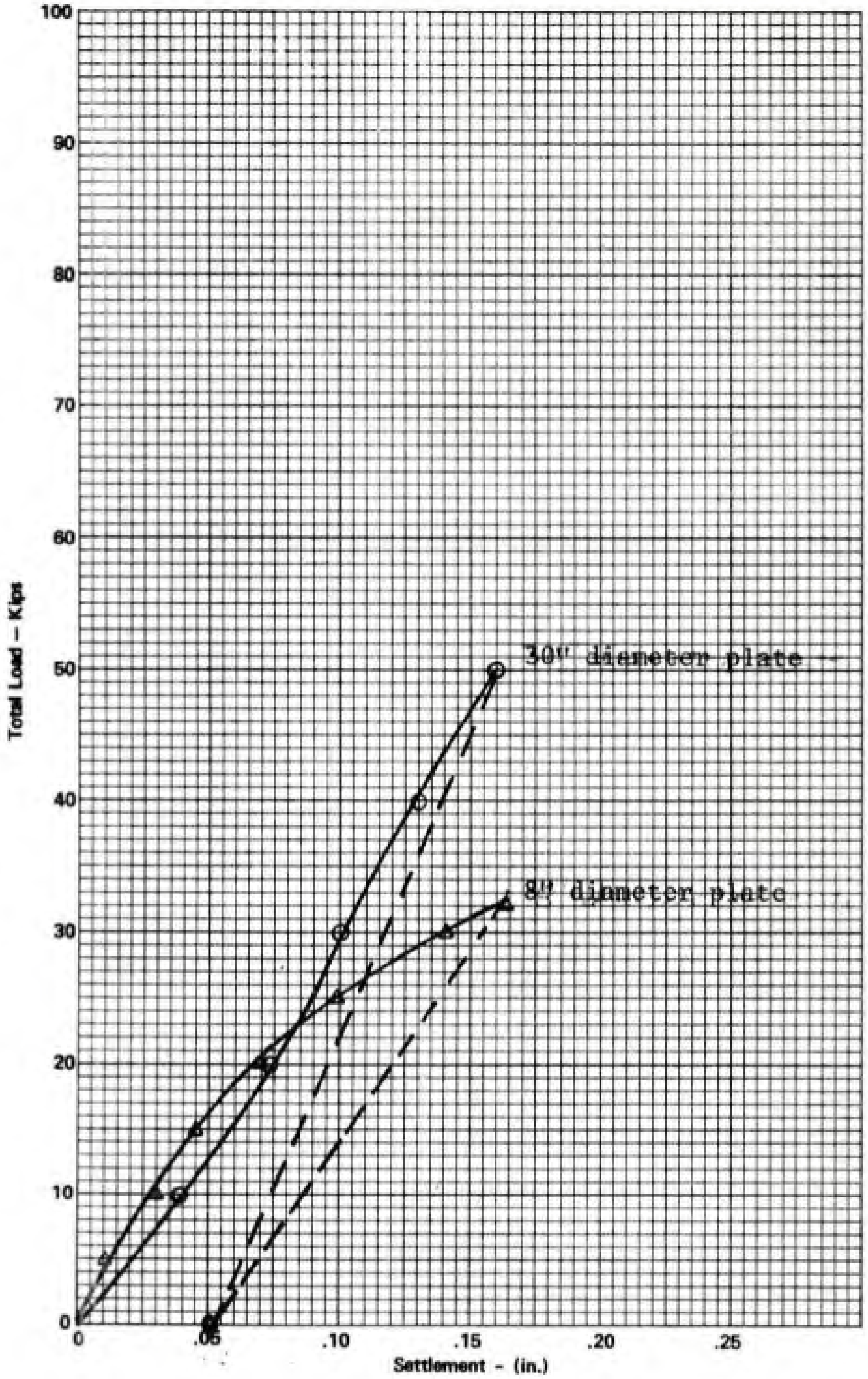
FACILITY	LOCATION	STATION
MCAS El Toro	Runway 7L -25R	62+00 25'R



11ND—NCEL—3960/20 (REV. 6-68)

TOTAL LOAD VS. DEFLECTION

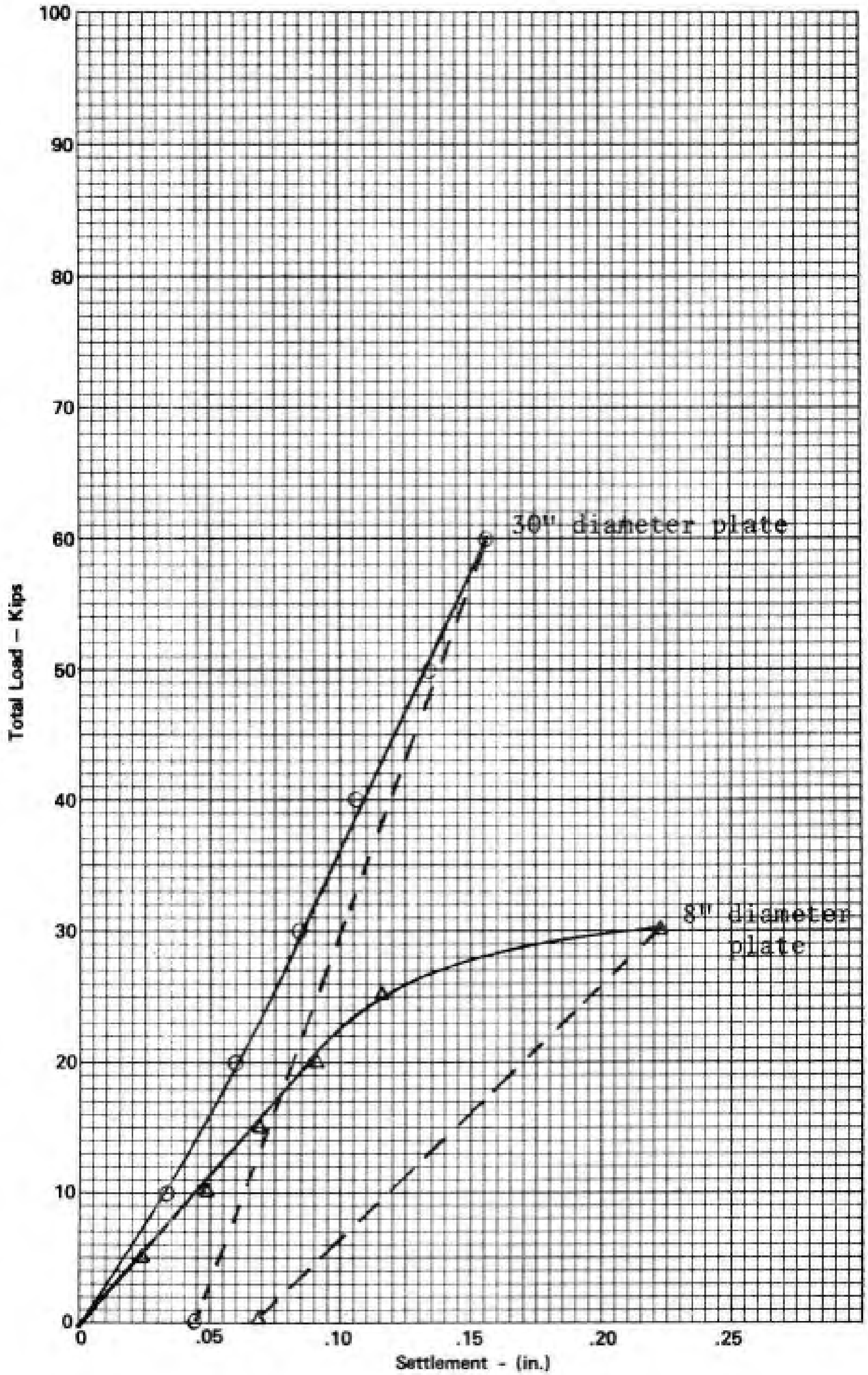
FACILITY	LOCATION	STATION
MCAS El Toro	Runway 7L-25R	62+00 25'L



11ND-NCEL-3960/20 (REV. 6-68)

TOTAL LOAD VS. DEFLECTION

FACILITY	LOCATION	STATION
MCAS El Toro	Runway 7L-25R	62 +00 ℄



APPENDIX F

ALLOWABLE AIRCRAFT
GEAR LOADS

11ND-NCEL-3960/21 (REV. 6-68)

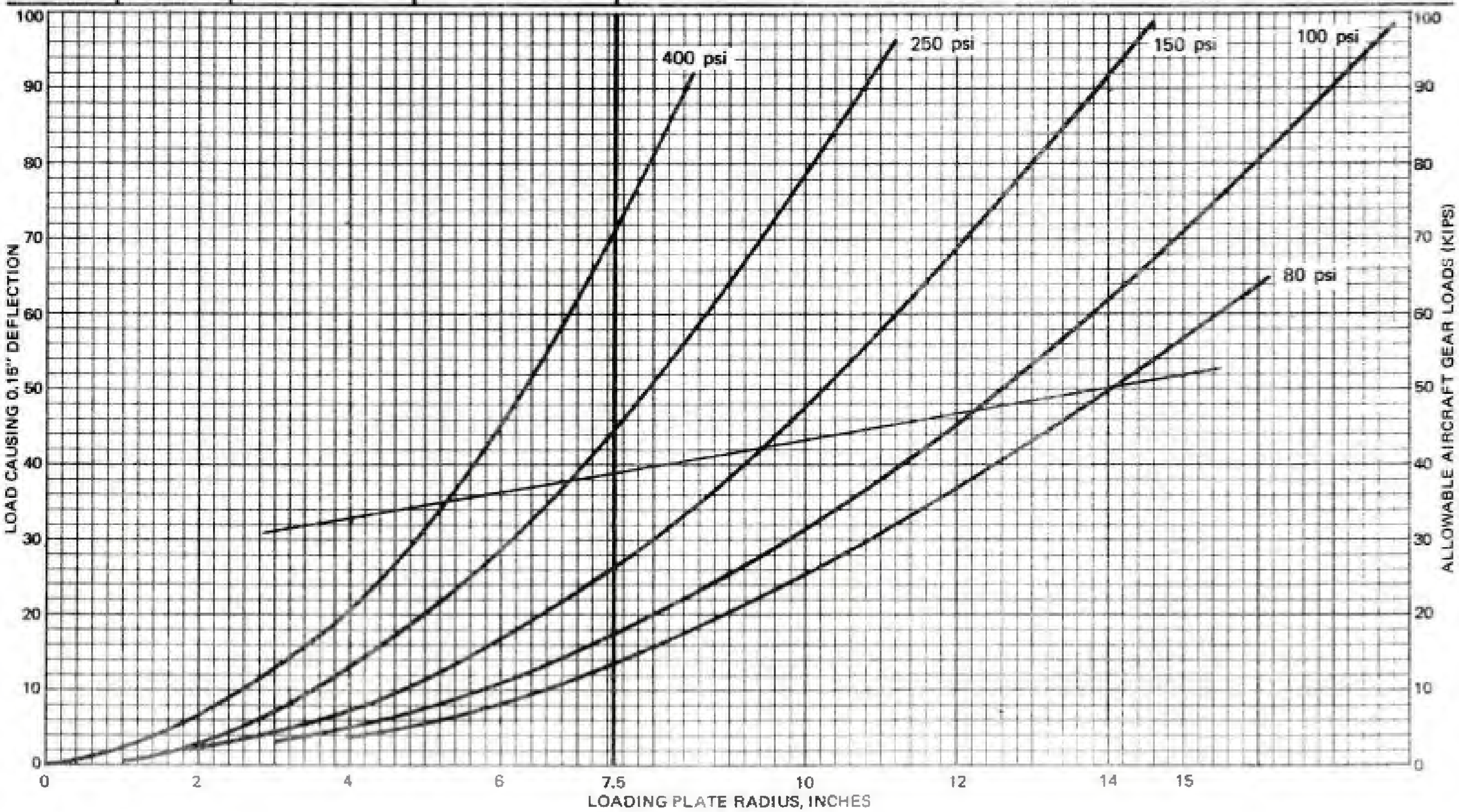
FACILITY	LOCATION	DATA
USMCAS El Toro, CA	Runway 16R-34L (discrete area R16R-1)	1975

ALLOWABLE AIRCRAFT GEAR LOADS (KIPS)

SINGLE WHEEL GEAR		DUAL WHEEL GEAR SWG x 1.30 150 PSI	DUAL TANDEM GEAR SWG x 1.95 150 PSI
150 PSI TIRES	400 PSI TIRES		
42.2	35.0	54.9	82.3

Note: Asphaltic Concrete Portion of Runway 16R-34L

GRAPHIC METHOD FOR DETERMINING ALLOWABLE SINGLE WHEEL LOADS



11ND—NCEL—3960/21 (REV. 6-68)

FACILITY	LOCATION	DATA
USMCAS El Toro, CA	Runway 7L-25R (Discrete Area 7L-2)	1975

Note: This area includes the asphaltic concrete portion of R/W 7L west of R/W 16L.

ALLOWABLE AIRCRAFT GEAR LOADS (KIPS)

SINGLE WHEEL GEAR		DUAL WHEEL GEAR SWG x 1.30 150 PSI	DUAL TANDEM GEAR SWG x 1.95 150 PSI
150 PSI TIRES	400 PSI TIRES		
42.0	33.5	54.6	81.9

GRAPHIC METHOD FOR DETERMINING ALLOWABLE SINGLE WHEEL LOADS